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Notes on Wastage of Non-Parasitic Origin in Stored Apples.

(*Continued from page* 182.)

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1. Superficial and Lenticel Scald.

Superficial Scald.

This superficial browning of the skin occurs principally in yellow varieties and has been met, in our experiments, on Granny Smith and Dunns, and to a much smaller extent on Cleopatra. It may develop as brown to almost black irregular spots or blotches, or as a general discoloration involving only the skin, and perhaps a few layers of cells beneath (Fig. 1, Pl. 1). In any case, it is removed when the fruit is peeled. Though unsightly and affecting the selling value, it does not normally affect the quality or keeping condition of the fruit.

Scald does not develop within the first two months or so of storage, and a thorough ventilation towards the end of this period tends to remove any subsequent liability. About August, and occasionally earlier in Western Australia, scald commences to appear on susceptible varieties, not specially treated, when removed from cold storage. From then onwards, the amount of scalding becomes more severe. In bad cases, it may appear while the fruit is still in store, but, in general, it follows the removal to higher temperatures.

Susceptibility to scald is increased with the immaturity of the fruit, the temperature of storage, and with a delay in placing in cold store if packed and closely stacked. Sunburn, even when hardly noticeable, appears to predispose apples to scald. We have noted this particularly with Granny Smith. Susceptibility is reduced if the apples are properly mature, if they are placed loosely in cases and in open stacks in well-ventilated sheds for seven to ten days before cold

storing, if cold-stored loose in cases and removed for a thorough ventilation after about five to six weeks and then returned to store, or if wrapped in anti-scald wrappers. It is generally accepted that scald is due to the excessive concentration in the storage atmosphere of the gases produced by the fruits themselves.

Fruit wrappers impregnated with an odourless mineral oil, first used by Brooks, Cooley, and Fisher (5), are a very effective means of control up to a point. The wrappers absorb the gases and prevent the injury therefrom until, after long storage, they can take up no more. The fruit may then rapidly become affected. For Granny Smith, the variety which has given most trouble in Western Australia, largely because the trade demand is for green and somewhat immature fruit, the following alternative procedures are suggested:—(1) Place the fruit loose in cases, which are then stacked loosely in a well-ventilated shed to allow plenty of air movement. After seven to ten days pack, using oiled wrappers, and then place in cold store. Or (2) stack for seven to ten days as before, and then cold-store loose in cases. After five to six weeks, remove to shed, pack in anti-scald wrappers, and return to store.

It is regrettable that two diseases are known as scald. The present form should be called superficial scald, as suggested by Tiller (18), to distinguish it from that form of breakdown known as deep scald. The two are distinct in appearance and origin.

The following results in relation to superficial scald were obtained in our experiments:—

Superficial Scald on Granny Smith, in Sulphite Wrappers (Karragullen, Western Australia).

Picked.	Percentage developed in two weeks after cold storage for—	
	Ten Weeks.	Six to Seven Months.
12.3.29 ..	Nil ..	52 (severe)
26.3.29 ..	Nil ..	51 (severe)
23.4.29 ..	Nil ..	53 (slight)

The figures indicate that the number of apples affected was not altered by the maturity of the fruit, but the falling off in severity was very marked. When sold in open market on 26th September, that picked 26th March obtained 15s. 9d. per bushel, as against 17s. 6d. for fruit picked 23rd April. The effect of ventilation is shown by the fact that a duplicate lot picked 23rd April, removed to an open shed for three weeks in July, and then returned to cold store for the remainder of the period, sold for 18s. 9d., as against 17s. 6d. per bushel for the continuously stored fruit. All the fruit in this experiment was packed within 24 hours of picking, using ordinary sulphite wrappers. The ventilated fruit was only 28 per cent. scalded, and that but slightly.

Superficial Scald on Dunns, in Sulphite Wrappers (Karragullen, Western Australia).

Picked.	Percentage developed in two weeks after cold storage for—	
	Ten Weeks.	Six to Seven Months.
12.2.29 ..	Nil ..	100 (very severe)
12.3.29 ..	Nil ..	100 (severe)
26.3.29 ..	Nil ..	11 (slight)

Slight scald developed in Cleopatras after six to seven months' storage in 1929 to the extent of 10 per cent in fruit picked 12th February, and only 1 per cent. in that picked 9th April. Lenticel scald was also present even more severely, falling to 5 per cent. in the last picking. Severe scalding, associated with shrivelling, occurred in 1930 on Cleopatras stored in sheds or cellars, both in our experiments and in commercial fruit. It was very slight in cold-stored fruit.

Lenticel Scald.

This is a form of scald which appears as a brown spot affecting the lenticels and the immediately adjoining skin (Fig. 2). It occurs alone, or in association with the normal form. Both forms have been noted on Granny Smith and Cleopatra, and the spotting form on Dougherty.

Affected lenticels are subject to fungal invasion. This has been noted in Cleopatra and Dougherty.

Lenticel scald is apparently identical with the lenticel spot of Kidd and Beaumont (10), which was recognized as being a spotting form of scald by Kidd and West (11), as the former authors had shown it to be controlled by anti-scald wrappers. It has been recorded on Yellow Newton and Bramley's seedling in England.

Clearly to distinguish this type of spot from Jonathan spot, with which it has apparently been confused by some workers, the name Lenticel Scald has been adopted.

Superficial Scald Generally.

So far as information is available, neither form of superficial scald occurs as a defect of Australian apples in Europe. If this is true, it is probably due to the long time factor required for scald, as such apples are rarely held at low temperatures for more than ten weeks. American apples in Europe have frequently been cold-stored for four to six months before they are sold, and, in consequence, scald may be a serious defect. Arkansas, Grimes, Newtown, Rome Beauty, Winesap, and York Imperial are recorded as susceptible in the United States of America (15). European trade reports indicate that the following were also affected in 1930:—Ortley, Ben Davis, Gano, Starks, and Baldwin. Jonathan, in the United States of America, is practically immune. In Canada, Grimes and Wagener are recorded as very susceptible, Rome Beauty moderately, and Jonathan and Delicious only slightly (14).

Victorian experiments in 1923 and 1924 (1 and 2) resulted in records of scalding on Rome Beauty, Stone Pippin, Buncombe, Rymer, Winter Majetin, and Jonathan. Unfortunately, no distinction was made between deep and superficial scald, and consequently these records cannot be used, though the descriptions and experimental results suggest that superficial scald occurred on all except Jonathan.

2. Jonathan Spot.

Confusion with Other Diseases.

Considerable confusion exists as to the exact identity of this disease. This was noted by Tiller (19), but he concluded that the different spotting troubles known under this name were probably "one disease

developed under slightly varying circumstances." A study of the available literature, combined with that of the spotting diseases met in our experiments, indicates that at least three have been known as Jonathan spot. These are distinguished as under:—

Jonathan Spot.
Lenticel Blotch.
Lenticel Scald (Lenticel Spot of Kidd and Beaumont).

The confusion appears to have originated in the original description of Scott and Roberts (16), which is indefinite enough to cover all three. This vagueness appears to have led workers, following the statement of these authors that "a lenticel usually forms the centre of each spot," to recognize any non-parasitic spotting disease as Jonathan spot if it involves the lenticels. Strange to say, the form which we, with Plagge and Maney (15), and Tiller (18), regard as Jonathan spot, because it is the form most frequent on that variety, is only casually associated with the lenticels. In the other two forms, the association is constant and specific.

Jonathan Spot.

The following description is based upon our experience and the descriptions of Plagge and Maney in North America, and Tiller in New Zealand.

Jonathan spot is a non-parasitic disease of certain varieties of red, or partially-red, apples, notably Jonathan and Esopus Spitzenberg. It is characterized by rather ill-defined greenish-yellow to brown or almost black spots, streaks, or blotches (Fig. 3). They are hardly depressed, and involve only the epidermal tissues. Though they may occur anywhere on the apple, they are much more frequent on the red than on the non-flushed surfaces, and not uncommonly more towards the stem than the calyx end. The lighter-coloured spots occur on the yellow surfaces, and the darker on the red. Though lenticels are necessarily involved in the larger spots and blotches, they are frequently absent from the smaller. Indeed, there is no evidence of any causal relation between the two.

Jonathan spot may develop on highly-coloured fruit on the tree, or on windfalls, but is mainly a storage trouble. Liability increases with the length of storage and with the intensity of the red colouring, and consequently with the maturity of the fruit when picked. Its onset does not affect the eating or keeping quality of the fruit. In our experience, the spots are not subject to fungal invasion. References in literature to rotting following spot appear to refer to lenticel blotch or scald. The spotting form affects the market value of fruit, and is apparently confused at times with bitter pit. The streaky form is confined to the red surfaces, and is often taken as part of the normal colouration.

The relations of Jonathan spot to fruit size, storage temperature, and storage humidity are somewhat uncertain, owing to apparently contradictory evidence. Plagge and Maney (15) found no consistent relation between size of fruit and susceptibility. McAlpine (13) noted that more small fruits were affected than large, an observation supported by our experiments in 1929.

Jonathan Spot in Jonathans (Karragullen, Western Australia).

Picked. Percentage developed in relation to size of fruit.

	Size 2¾ inches.		Size 2½ inches.		Size 2¾ inches.	
	B.		A.	B.	A.	B.
12.2.29	7		Nil	2	Nil	—
19.2.29	—		Nil	10	Nil	—
26.2.29	—		1	18	2	10
5.3.29	—		7	43	10	—
12.3.29	—		9	46	4	30
19.3.29	63		51	54	17	—

Counts made two weeks after removal from A., ten weeks, and B., six to seven months, in cold store. The mean storage temperature ranged from 33° to 36° F. No spot developed in shed-stored fruit at 50° to 90° F.

In 1929, a year of intense colouring in Jonathans, spot was common. In 1930, the fruits were less coloured, and the colouring was less intense. No spot was noted either in our experiments or in commercial fruit. Plagge and Maney found that practically the same percentage of apples were affected at 40° as at 32° F., but the spotting was more severe at the higher temperature. Adam (1), in Victoria, and Tiller (18), in New Zealand, found no relation to temperature. Conflicting results have also been obtained in relation to storage humidity. Tiller found no consistent relation to variation in humidity at 32°, while Plagge and Maney obtained more spot at higher than lower humidities at both 30° and 80°.

In addition to Jonathan and Spitzenberg, Plagge and Maney have recorded Jonathan spot on Rome Beauty and King David. Other records of its occurrence on different varieties appear unsafe owing to the uncertainty as to the identification of the disease.

Jonathan spot has been recorded as occurring in Australian apples in England, particularly in Jonathans from Western Australia (9). Here, again, there is some doubt as to the identity of the disease. The amount present in 1927 in the Western Australian fruit is stated to have fallen from 15 per cent. in the earlier and more immature shipments, to 5 per cent. in the later and more mature. In an unpublished report from the Low Temperature Research Station of the British Department of Scientific and Industrial Research, it was recorded as occurring in Victorian Jonathans shipped towards the end of February, 1928, and therefore immature, an opinion confirmed by the presence of bitter pit in some of the lines. This association with immaturity suggests that the trouble was lenticel blotch rather than Jonathan spot.

3. Lenticel Blotch.

This name is proposed for a spotting disease (Fig. 4) found by us on Jonathans and Spitzenberg in Western Australia, and on Spitzenberg from Victoria. It appears to be, at least in part, the Jonathan spot of Brooks and Cooley (4), McAlpine (13) and Carne, Pittman and Elliott (6). Fig. 3 in the last publication, entitled "Jonathan spot on Spitzenberg," in reality illustrates blotch. McAlpine gives an excellent colour plate (13) of blotch, which he apparently regarded as

a form of bitter pit. As stated under Jonathan spot, it is possible that the disease recorded as spot on Australian apples in England (9) may be really blotch.

Though it has a superficial resemblance to spot, blotch differs markedly in detail. The lesions tend to be developed towards the calyx end of the fruits, and without any definite relation to the coloured areas. In many examples, the non-flushed areas have been the more affected. Each isolated lesion has a lenticel in its centre. They are larger than the spots of the spotting form of Jonathan spot, and are frequently, almost typically, confluent, forming irregular blotches up to 1 cm. or more in greatest diameter. They are sharply defined, and definitely depressed though involving only the skin and a shallow layer of cells beneath (Fig. 5). Fungal invasion is not infrequent, and the spots then take the circular form common to fungal rots.

Nothing is known as to the cause of this defect, but its common association with bitter pit suggests that they have something in common. In our experiments, it has occurred mainly in shed-stored fruit (see below), and only to a slight extent in fruit placed in cold store within a week of picking. It has occasionally been noted in Jonathans during the inspection of fruit for export.

Lenticel Blotch and Bitter Pit in Jonathans Stored in Shed, Karragullen, Western Australia.

(From same trees in both years.)

Picked.	Total per cent. Blotch.	Total per cent. Bitter Pit.	Total per cent. Pit & Blotch	Per cent. Blotch only.
12.2.29	4	37	?	?
19.2.29	18	29	?	?
26.2.29	13	18	8	5
5.3.29	6	13	5	1
12.3.29	14	13	6	8
19.3.29	6	11	3	3
30.1.30	2	6	2	Nil.
13.2.30	3	11	2	1
27.2.30	2	0	0	2

Apples 2½ inches diameter in 1929, 2–2½ inches in 1930, except pick of 13.2.30, which had 2¼–3 inch fruit. The pit in this picking was distributed as follows:—2¼ inches, 2 per cent.; 2½ inches, 5 per cent.; 2¾ to 3 inches, 30 per cent.

4. Split Core and Mouldy Core.

Some varieties of apples are subject to a rupturing of the core, which is usually confined to the cartilagineous endocarp. Not infrequently, however, the rupture extends to the fleshy parts of the core, and even into the cortex. Such varieties have usually an open calyx tube, which allows the spores of various common rot fungi to enter the core cavities. When the ruptures extend into the flesh, the fungi may attack it and set up a general rot. Cleopatra is a variety very subject to core ruptures, and in our experience with it the following conditions have been found:—

(*a*) A transverse cracking of the endocarp, indicated by white streaks known as "woolly stripe" (7). The white streaks are produced by loosely-packed protruding cells. As the fruit matures,

these cells turn brown. Woolly stripe is so common in Cleopatra as to be a normal characteristic of the variety, at least as grown in Western Australia. No evidence has been obtained that fungi ever succeed in growing into the flesh of the fruit through these cracks in the endocarp.

(*b*) A pulling apart of the five sections of the endocarp, so that instead of it consisting of five closed seed compartments, a five-lobed open cavity is formed. This condition is known as "hollow core." Not infrequently, weak fungal growths may be found in the cavity, discolouring its walls, but not penetrating the flesh or affecting the selling value of the fruit.

(*c*) The development of longitudinal cracks at the points of the endocarp lobes in hollow-cored apples (Fig. 6). These ruptures occur most frequently at the calyx end, at the top of each lobe. Less frequently they develop at the stem end. As a result of this splitting of the endocarp, the flesh of the core is more or less exposed, and may itself be ruptured. In the absence of fungi, the ruptured flesh becomes brown and corky, and no further deterioration of the fruit results. This is the condition referred to by Smith (17) as "an undescribed core disease," and by us as "flesh rupture" (7). The name "split core" is now suggested for any rupture of the endocarp involving the fleshy parts of the core (Fig. 6). In our experience, the percentage of split core in Cleopatra does not vary greatly in any season, but the amount of flesh rupture, i.e., the size of the cracks, is markedly increased in light as compared with heavy crops. In 1930, the Cleopatra crop was relatively light, and the development of split core became economically important, leading to the rejection of fruit, both in the orchard and during the inspection of export fruit. Marked split core not only affects the apples commercially because of the large core cavities and flesh ruptures extending in bad cases almost to the skin, but also because of the high susceptibility of the affected apples to "mouldy core." Fungi attack the flesh from within the endocarp, and cause rots which finally extend to the skin.

In severe split core, the greatest rupture tends to take place in the same plane on opposite sides of the core, so that two carpels split badly, dividing the fruit into two halves—one with one end, and the other with two more or less normal seed cavities. In more severe cases, one or two more carpels split, forming ruptures at right angles to the first. Splitting occurs some time before the fruit reaches full growth, with the consequence that badly affected fruit tends to become irregular in shape. This fact enables many to be discarded by the packer, and is the only external aid to the recognition of split core during the inspection of export fruit. The irregularities take the form of depressions at the calyx end, in the same planes as the cracks, while the fruit as a whole tends to be flattened adjacent to the cracks.

The following table indicates the relation of size of crop to the development of mouldy core. The fruit in 1928 and 1930 came from the same trees; that in 1929 from different and larger trees in the same orchard. In no year did the rainfall reach 1 inch in any month from December to March.

Percentage Split Core and Mouldy Core in Relation to Size of Crop (Cleopatra), Karragullen, Western Australia.

Stored in Shed, 50° to 90° F.

	1928.	1929.	1930.
Average crop per tree ..	8 bushels	14 bushels	4 bushels
Stored	6 weeks	5 weeks	8 weeks
Percentage split core only	23	20	22
Percentage mouldy core	2	1	6

In 1930, 50 per cent. of the fruit with mouldy core had rotted to the skin.

Mouldy core has also been recorded in Australia in Annie Elizabeth and London Pippin (8 and 12).

5. Fungal Rots.

Fungal rots in apples usually follow mechanical injuries or storage diseases. The principal exception is mouldy core, which has its origin in defects developed during the growth of the fruit. The onset of fungal rots in land stores and during shipment overseas is related to the temperature and humidity of the storage atmosphere.

Injuries, in the main, are due to carelessness in packing and in handling the fruit from the time of picking to its final disposal through retail channels. The storage diseases which predispose fruits to fungal rotting are mainly breakdown, lenticel scald, and blotch.

Contact with the commercial handling of fruit soon makes evident the many opportunities for bruising and other injury. From the time of picking, the risk of injury is always present, and the wonder is, not how much has occurred, but rather how little. Provided the fruit is carefully handled to the packing bench, the best insurance against injury, under the conditions at present existing, is good packing. Over-tight packing is a frequent cause of bruising, especially in hardwood cases. Loose packing, on the other hand, is liable to cause bruising when the boxes are roughly handled, besides causing complaints as to get-up and shortage of weight. To reduce the danger of bruising when nailing on the lids of the boxes, several precautions can be used. Corrugated strawboards, especially on the tops and bottoms, will reduce the pressure on the fruit. The strawboards should be carefully placed. Cases have been noted where they have slipped to one side and the edge has cut into the outer row of fruit on the opposite side. When nailing up, the box should be supported on its ends, so as to allow the bottom board to bulge when the lid presses on the fruit.

Low temperatures tend to reduce and high humidities in the storage air to encourage rotting.

6. Wastage in Australian Apples Exported Overseas.

From reports by the trade, by the High Commissioner and Agents-General, by the Empire Marketing Board (9), and published and unpublished reports by Dr. Barker (3) of the Low Temperature Research Station of the Food Investigation Board of the British Department of Scientific and Industrial Research, it is very evident

that a serious amount of wastage occurs in Australian apples exported overseas. It develops not only during transit, but also in the period between unloading and retail distribution. The principal defects are bitter pit, breakdown, and fungal rots. Relatively minor defects are skin-marking, caused by fungi like black spot and by spray burn; insect pests, as codlin moth; and non-parasitic diseases, such as deep scald, freezing injury, Jonathan spot (?), and brown heart. Superficial scald apparently does not occur.

We have shown that breakdown comprises a number of forms, each associated with specific conditions. The evidence available indicates that those originating in bitter pit and water-core are the most important in exported fruit. Brown heart, caused by an excessive accumulation of carbon-dioxide in the holds, is now rare and inexcusable. At one time it was the predominant form of breakdown, but liability has almost disappeared with the introduction of controlled ventilation into routine practice in refrigerated holds. Fungal rots have their origin mainly in mechanical injuries or defects of physiological origin, such as breakdown, lenticel blotch, and split core. They are checked by both low temperature and low humidity of the atmosphere. The main market defects are thus primarily due to the defective pre-storage condition of the fruit and to defective handling, though they may be aggravated by the storage temperature and atmosphere. The main primary defects operate as follow:—

Bad packing and careless handling leads to bruising and fungal rots.

Premature picking leads to poor colour; if the fruit is held too long at ordinary temperatures, before or after shipping, to shrivelling and slack packs; to bitter pit and subsequent liability to breakdown and fungal rots; to lenticel blotch and liability to fungal rots.

Water-core in fruit when picked leads to breakdown and fungal rots, and probably to deep scald.

Split core in fruit when picked leads to liability to mouldy core and rotting.

Over-maturity of the fruit when picked may lead to the serious occurrence of Jonathan spot in susceptible varieties.

Over-maturity of the fruit when picked or when placed in the refrigerated holds increases its liability to bruising, and consequently, to fungal rots.

To eliminate these primary causes of wastage, the following precautions should be taken:—

1. The fruits should be clean, sound, of good shape and colour for the variety, and sufficiently mature when picked. While avoiding immaturity, with its liability to cause shrivelling, bitter pit, and lenticel blotch, care should be taken to avoid over-maturity. Over-mature apples are unduly liable to bruising, fungal rots, water-core with subsequent breakdown, and to develop a mealy texture with a lack of flavour and freshness.

2. Special care should be taken, especially with light crops of quick-maturing varieties like Jonathan, to avoid an undue amount of water-core to which they are liable when maturing. It is better to pick such

varieties on the immature side in seasons when water-core is prevalent if they are to be exported, but if the market conditions are reasonably good, it would be much safer to market them locally.

3. The fruit should be carefully handled, graded, and packed. Grading should be on the basis of colour as well as size, as this leads to uniformity of appearance, maturity, and keeping quality. Over-tight and loose packing should be equally avoided. Corrugated strawboards should be used at least on bottoms and tops, and care taken when nailing down to avoid bruising.

4. Several pickings should be made to secure uniformity of maturity and colour. If congestion of work prevents picking as the fruit becomes ready, yellow varieties among the earlier sorts, like Dunns and Cleopatra, should be left on the trees and picking concentrated on the poorer keeping varieties like Jonathans, Cox's Orange Pippin, and Gravenstein. These latter, owing to their high liability to shrivelling, bitter pit, breakdown, and poor colour when picked immature and to bruising and breakdown when over-mature, have a very short safe picking period. In Western Australia, the main crops of these varieties have a safe picking period of not more than a week under the normal conditions of temperature for February and March. Cleopatra, though pit liable, is breakdown-resistant. When immature, it suffers less from colour defects than the red varieties. When ready, picking may be delayed two or three weeks, or until loss by windfalls becomes excessive. Dunns and Granny Smith lose their pit-liability and will mature normally if picked while still hard and nearly full green. They may consequently be picked over a relatively long period. In short, apples should be picked according to their varietal characteristics. The picking programme should be based upon the quick-maturing poor-keeping varieties, and the others should be fitted in as convenient. In planting an orchard, one aim should be to provide a series of varieties cropping more or less in succession, rather than to have groups of varieties maturing together. If export is intended, care should be taken to select the best export varieties and to avoid those which may be already overplanted, such as Jonathan.

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Collapse of Timber.

A Major Cause of Waste in the Australian Timber Industry.

By C. Sibley Elliot, B.Sc.*

1. Evidence and Occurrence.

Certain timbers, in drying, are prone to suffer a severe flattening or sinking-in of the the cells, such as can be induced by crushing a piece of timber in a vise. This results in an excessive and frequently irregular form of shrinkage, for which the name of collapse has been adopted.

The irregularity of surface which is the outward evidence of collapse varies in type, as illustrated in Figs. 1 and 3 (Plates 3 and 4), but while it is a common feature of collapsed timber, excessive shrinkage unaccompanied by any marked irregularity commonly occurs. In such cases, there is little or no microscopic evidence that collapse has occurred, though its effect may still be quite serious. As a general rule, quarter-sawn boards develop greater irregularity due to collapse than do back-sawn boards, and it is in the latter that collapse unaccompanied by irregular shrinkage is most often found.

Since size reduction due to collapse is usually much greater than that due to ordinary shrinkage, the former is liable to be much more serious in practical effect than is the latter, from which, as is indicated in a later section, it is quite distinct.

Because wet wood becomes more or less plastic at high temperatures, kiln-drying timber green from the saw causes more severe collapse than does air drying, or partially air drying and then kiln drying; also, timber dried under a high temperature high humidity schedule will collapse more severely than under a lower temperature schedule. But it must not be overlooked that collapse occurs to a serious extent in air-dried stock.

Collapse is not confined to Australian timbers, but it is probably a more serious factor in Australia than in any other country, some of our most important commercial timbers commonly being affected seriously by it. Outstanding amongst these are certain members of the "ash" group of eucalypts, e.g., mountain ash (*Euc. regnans*) and red ash (*Euc. gigantea*). In these, at least, the evidence is that young timber collapses more severely than old, and material from top logs more severely than that from lower in the tree. Certain overseas trees, on the contrary, have a very high moisture content in the butt logs owing to their growing in swampy country, and show the most severe collapse in boards from near the butt.

2. Economic Importance.

From the Australian stand-point, the economic importance of collapse has two distinct aspects. One is that of waste, the other that of the reception, on both the home and overseas markets, of some of our most abundant and valuable timbers.

The additional size allowance which many millers find it necessary to make in sawing timber which is prone to collapse, commonly amounts to more than 20 per cent. over and above the allowance necessary to

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cover ordinary shrinkage and machining. In cutting for flooring stock, to obtain a finished machined size of 4¼ inches x ⅝ inch, the miller sawing timber which does not collapse can saw to a green size of 5 inches x 1 inch in quarter-sawn stock. To obtain the same finished size from timber which collapses, it is necessary to increase the green size frequently to as high as 5 5/16 inches x 1 3/16 inches or 5¼ inches x 1¼ inches; even then it is sometimes necessary to re-mill some of the stock to a smaller finished size. This alone causes a tremendous loss of timber. There is an additional factor, dependent on the greater severity of collapse of top logs of the "ash" group. So severe is this at times that it is common practice to relegate to a lower grade timber cut from high in the tree, even from logs below the first limbs. For example, there are cases where such timber will not be accepted for flooring, lining, and weatherboards, solely on account of the severity of collapse which occurs. Thus, collapse is responsible for the lowering in grade, and therefore in value, of a considerable proportion of the timber in trees of these species.

At a time when appearance counts for much towards the acceptance of a product on the open market, it is not difficult to understand the tremendous disadvantage which collapsed timber carries. This is even a greater factor in influencing the overseas buyer than it is on the Australian market. Added to the unattractive appearance of collapsed timber, there is the fact that a buyer is likely to lose heavily as a result of timber not standing up to size. There are definite and recent cases of timber being shipped to England on consignment and finding no place on the market, simply because of collapse which occurred during transport.

It might seem illogical to refer to timbers exhibiting such a derogatory feature as being amongst our most valuable commercial timbers. That we can continue to place them in this class is due to the development, on a commercial scale, of a simple treatment by which collapse can be overcome. While it cannot be said that this treatment has been perfected, yet it has been developed sufficiently to be put into practice successfully, and it is being adopted widely in Victoria and Tasmania. From the point of view of individual millers, and from the wider one of making the most of our forest resources, it is important that this treatment should be adopted wherever timber which collapses is being milled.

3. Collapse and Shrinkage.

In considering the treatment of timber to overcome collapse, it must be understood that collapse differs distinctly from normal shrinkage, and whereas the former can be overcome the latter cannot by any known means, though it can be slightly reduced.

The essential differences between the two are:—

(i) Ordinary shrinkage is unaccompanied by any marked distortion of the cells, whereas such distortion, detectable by microscopic examination, is the feature from which collapse takes its name.

(ii) Ordinary shrinkage does not commence in any particular zone in a piece of timber until all the free moisture has been removed from the cavities of the cells in that zone; collapse, on the other hand, becomes evident long before all the free moisture has been removed from the cell cavities.

(iii) Ordinary shrinkage cannot be eliminated, though it can be reduced slightly, and timber will continue to shrink and swell with changing atmospheric conditions; collapse can be overcome simply, and once removed under the correct conditions will not reappear, though it can be induced by artificial conditions.

Although questioned for some years, the finality of these distinctions has been definitely established. Microscopic examination reveals the first in a striking manner. As regards the second, collapse has been observed when tests showed the moisture content to be as high as 89 per cent. Finally, it has been shown, not only that after the removal of collapse normal shrinkage still remains (c.f. Table 1), but also that, whereas collapse can be permanently removed by a steaming treatment, if collapsed boards be soaked in hot water until the cells are filled with water the collapse will be removed temporarily, but will reappear with great severity on redrying.

Explanation of the stresses necessary to cause collapse of the cell walls has been a more difficult problem, but the theory first put forward by H. D. Tiemann* seems to fit the facts and is the only one to date to which credence can be given. It is based on the proved experimental fact that if from a system of fine tubes filled with water the water be removed without air being allowed to enter, there will be set up not only the small external pressure due to the creation of a vacuum, but a very great tensile stress due to the cohesive tendency of the film of water lining the tubes. Tiemann's theory assumes these conditions to exist in the drying of a piece of timber with an initially high moisture content, the cells being the fine tubes. In the case of timber, the essential factors, variation from any one of which would account for a particular timber not collapsing, are very high initial moisture content, cell structure of such a nature as to preclude the entry of air as the timber dries, and a fibre strength insufficient to withstand the stresses set up, other conditions being suitable for their development.

4. Experimental Investigations of Treatment.

(*a*) *Early Development of Method.*—To Mr. Grant, Senior (now of East Warburton, Victoria), and to his son, Mr. George Grant (now of Alexandra, Victoria) belongs the credit of having discovered and developed a method of obtaining permanent recovery in size of collapsed timber. The treatment developed by them—for which the term "reconditioning" has been generally adopted—consists of steaming the timber, after it has been dried to a moisture content of 10 to 12 per cent. or lower, for a period dependent on the severity of the collapse and on the thickness of the stock.

At the time of Mr. H. D. Tiemann's visit to Australia at the invitation of the Forests Commission of Victoria, Mr. Grant and his son were putting this treatment into practice at the plant of Cuming Smith and Co. Pty. Ltd., East Warburton, Victoria. The treatment was explained to Mr. Tiemann when visiting this plant, and he was so impressed with its importance that further investigations were immediately commenced at the Forests Commission's experimental kiln at Newport. The Forests Commission has kindly consented to the inclusion in this article of information gathered during these experiments,

* Dry Kiln Expert, Forest Products Laboratory, Madison, Wisconsin, U.S.A.

which were continued by the writer after Mr. Tiemann's departure. The whole of the experimental work done to date by the Division of Forest Products has been with the co-operation of Mr. George Grant, and has been carried out at the plant of Clarke, Pearce, and Grant Bros. Pty. Ltd., of Alexandra, Victoria.

The first experiments carried out by the Forests Commission of Victoria were to determine the efficacy of the treatment and the period necessary. These experiments showed that on an average, by steaming at a temperature between 190° F. and 200° F., it took about 48 hours for badly collapsed 1-in. mountain ash boards which had previously been dried to a moisture content of 10 per cent. to regain completely their original regular shape. In all of these tests the moisture content of the boards when collapse was just overcome was in the vicinity of 30 per cent.* On re-drying to the original moisture content of 10 per cent., the boards retained a regular shape and showed a big increase in size as compared with the original collapsed size. In a few cases of excessive collapse, no amount of steaming at these temperatures would remove it completely. The following table shows the results for a representative board.

TABLE 1.

—	Initial Collapsed Stock.	After 24 hours' Steaming.	After 48 hours' Steaming.	After 64 hours' Steaming.	After Re-drying.
Moisture content .. %	10·5	23·3	35·9	44·9	11
Width .. .. inches	$6^{15}/_{32}$	$6\frac{7}{8}$	7	7	$6\frac{3}{4}$
Gain in width .. %	..	..	..	..	4·35
Thickness at edge .. inches	$^{23}/_{32}$	$1\frac{1}{32}$	$1\frac{1}{32}$	$1\frac{1}{32}$	$^{29}/_{32}$
Gain in thickness .. %	..	..	..	..	26·1
Radial shrinkage per cent. of green size .. .. %	7·6	..	..	..	5·6
Tangential shrinkage per cent. of green size .. .. %	28·1	..	..	..	12·1

These figures are for a quarter-sawn board, and the gain of 26.1 per cent. in thickness represents the gain at the edge, which is considerably less than the gain in from the edge.

A better idea of the actual gain in size due to reconditioning is given by Figure 2. In this, the top pieces of the pairs were cut off collapsed boards at the end of a kiln run prior to reconditioning, the average moisture content then being 7 per cent. The bottom pieces of the pairs were cut off corresponding boards after reconditioning and re-drying to an average moisture content of 11 per cent. The photograph shows very well the gain in size of timber which, though obviously collapsed, did not exhibit any marked irregularity. It also shows an additional advantage in the straightening of cupped boards.

There are actually four definite advantages to be gained by the reconditioning of collapsed stock. First, there is the gain in size; secondly, the straightening out of cupped and twisted boards; thirdly, a reduction in the amount of swelling which will occur if a board is placed in a moist atmosphere after being machined; fourthly, a mellowing of the timber, improving its working qualities considerably.

* More recent tests have shown that where collapse is not severe it may be overcome sufficiently for practical requirements without taking the moisture content above about 12 per cent.

The time (about 48 hours) indicated by these tests as being necessary to overcome severe collapse completely is very much more than that taken by the various commercial concerns which have now adopted the treatment. Most of these have adopted an eight-hour steaming period, and some have reduced it to four hours. It has generally been maintained that the difference in time is accounted for by the higher temperature being used in practice where the steaming is carried out at 212° F. as against 190° F. to 200° F. in the above experiments. There is definite indication that at a temperature as low as 160° F. the treatment takes very much longer than at 200° F. But it is yet to be proved that the difference between 200° F. and 212° F. accounts for a decrease in time from 48 hours to eight hours, still less to four hours. It has, on the other hand, been found that in a number of cases the eight hours' treatment at 212° F. did not completely remove even moderate collapse, though it had sufficient effect to bring stock up to the required size. This is undoubtedly a large factor, if not the main one, in accounting for the apparent discrepancy between experimental and commercial times.

It is commonly thought that the high temperatures used in reconditioning might seriously affect the strength of the timber. Observations to date do not bear this out, and of about two dozen cross-bending tests carried out in comparison of the strength of collapsed pieces with reconditioned pieces cut from the same boards, there was no indication of weakening of the timber by the treatment.

It has been found that back-sawn boards sometimes check badly during re-drying following the steaming, and precautions are sometimes necessary to prevent this. Where sawing on the quarter is the practice, no difficulty is experienced from this cause, and even with back-sawn timber, so far as eucalypts of the " ash " group are concerned, the question is only one of careful re-drying.

(*b*) *Further Developments.*—There is, however, one feature of reconditioning that can, and frequently does, have serious consequences. This is the setting up of surface tension stresses, which are sometimes so severe that boards planed unevenly on opposite sides cup considerably as they come off the machine. The investigations of collapse carried out by the Division of Forest Products have aimed mainly at eliminating or reducing these stresses, and to date the results are very promising. It is not necessary, for the purposes of this article, to give details of the considerable amount of work involved, but the following outline covers the salient points.

The investigations were commenced by a thorough test of a kiln charge of 1-in. stock in which the surface tension stresses were so severe as to cause immediate cupping of boards 4 inches wide when they were planed unevenly on opposite surfaces. This stock had been reconditioned by four hours' steaming at 212° F. at the end of the kiln run, and it was found that the moisture content of cores* of boards ranged from 3 per cent. to 7 per cent. and that of cases (i.e., of the outside) from 9 per cent. to 15 per cent. It seemed probable that the four hours' steaming had resulted in absorption of moisture by the outer layers only, and that prior to reconditioning the moisture content of the outside layers had been at least as low as that of the cores. This

* For the purposes of this article core moisture content means the moisture content of the central third of a section cut into three equal pieces parallel to the width of the board, pieces equal in depth to its thickness being cut from the top and bottom of the core. Case moisture content means the moisture content of the two outside thirds.

view was supported by a test of two other kiln charges of 1-in. stock at the end of the kiln runs but before reconditioning, which showed core moisture contents to vary from 3 per cent. to 6½ per cent. in one instance and from 5½ per cent. to 11½ per cent. in the other, while corresponding case moisture contents varied from 3½ per cent. to 6½ per cent. and from 2 per cent. to 7 per cent.

The second charge was then reconditioned by two steaming treatments, totalling 13½ hours, at a temerature of 212° F. This resulted in absorption right to the centre of the boards, the minimum core moisture content being increased from 3 per cent. to 9 per cent. and the maximum from 6½ per cent. to 15 per cent.; the corresponding increases in case moisture content were from 3½ per cent. to 13 per cent. and from 6½ per cent. to 17½ per cent. respectively. On machining, this stock did not cup at all, but after standing for several weeks there was a slight change in the boards of highest moisture content, due to drying, and a small amount of very slight cupping occurred. The charge was a distinct improvement on the first, however, cupping due to surface tension stresses at the time of machining having been eliminated.

The third charge was reconditioned by a steaming treatment of eight hours at a temperature of 212° F. Following this steaming, portion of the charge was placed in a kiln for sixteen hours, and then the truck was stood in a shed until cool; portion was kept under shelter for sixteen hours and portion was kept under shelter for three and a half days. These portions were tested and machined at the end of the respective periods. Absorption had extended to the centre of boards in this treatment also, the minimum core moisture content having increased from 5½ per cent. to 8½ per cent. and the maximum from 11½ per cent. to 13 per cent. All boards remained straight when machined and also after standing for several weeks, and there was nothing in their behaviour to indicate preference for any one of the three treatments given subsequent to the steaming. Prong tests*, however, indicated that the boards which were kept under shelter for three and a half days before testing were in somewhat better condition than were the others. In the above three charges, the amount of initial collapse was slight, and those boards which showed even moderately severe collapse did not recover fully in the time.

These investigations seem to indicate that surface stresses due to reconditioning may be almost, if not completely, eliminated by continuing the steaming until the centres of the boards have absorbed sufficient moisture to bring their moisture content to within about 2 per cent. to 3 per cent. of that of the case. This applies in reconditioning timber which has an initial core moisture content below 10 per cent. to 12 per cent., but the whole question of reconditioning as soon as the core moisture content is below fibre saturation point (25 per cent. to 30 per cent.) has yet to be investigated, both from the point of view of stresses and from that of costs. While in the above tests collapse was overcome sufficiently for practical requirements by the time the moisture content was increased to about 12 per cent., had the collapse been more

* The prong test consists of cutting a section about ½" to 1" long off a board, and slotting this from one edge to within about ¼" of the other edge, by two or more slots parallel to the original length of the board. The behaviour of the prongs at time of cutting indicates the state of stress in the board, an outward turning indicating surface tension and an inward turning or nip indicating surface compression. This test has been in use for a considerable time and has undoubted value, but there is some evidence that it is influenced by certain conditions, such as the temperature of the wood. Further investigation of it is necessary.

severe it would have been necessary to have continued the treatment for a longer period, with a resultant increase in moisture content.

As far as treatment of the timber after the steaming is concerned, there is a decided benefit gained by allowing the timber to stand, racked out under shelter, for several days before machining. It is reasonable to assume that for these several days under ordinary atmospheric conconditions, a shorter period under regulated conditions in a kiln could be substituted.

During the course of preparation of this article, the reconditioning of a charge of 1-in. jarrah (*Euc. marginata*) has been completed. The treatment consisted of eight hours' steaming subsequent to kiln drying. After steaming, the truck of timber was held in the reconditioning chamber, with the door open and the steam turned off, over night, and was then run under shelter. Prong tests made the following afternoon showed a considerable outward turning of the prongs, whereas in similar tests made with portion of the stock which was kept under shelter for several days the prongs remained practically straight, both at the time of cutting and after standing. The first prongs cut did not straighten on standing, but tended to turn out more.

One other point still requiring investigation is that of the necessity of, or gain occasioned by, having timber cold at the commencement of the reconditioning treatment. This has been stated to be a necessity, but it is possible that it is simply an advantage, due, perhaps, to more rapid absorption at the beginning of the treatment. The question is complicated by the fact that some plants finish their kiln drying at a temperature of over 220° F., whereas others do not go above 150° F.—a difference which might influence observations.

5. Practical Treatment.

The simplicity of the Grant method of reconditioning collapsed timber makes it of easy commercial application, and, in Victoria alone, it has been adopted by plants with an aggregate annual output of approximately 10,000,000 super. feet.

Under the section devoted to the economic importance of collapse it was stated that some millers had found it necessary to cut stock to a green size of 5¼ inches x 1¼ inch where a green size of 5 inches x 1 inch would be sufficient in a timber not prone to collapse. Some of these millers have now adopted the reconditioning treatment and, as a result, have actually reduced their green size for this stock to 5 inches x 1 inch. One could not wish for a sounder argument in favour of the general adoption of the treatment for timbers of the "ash" group. Its effectiveness has also been proved for other timbers. Air-dried stock, provided it is sufficiently dry, can be treated as effectively as kiln-dried stock, but in either case the moisture content must be at least as low as 25 per cent. to 30 per cent. before the treatment is given.

The only requirements for carrying out the treatment on a commercial scale are a steaming chamber and a sufficient steam supply. For the steaming chamber, wood construction can be used provided care is taken to protect the wood from steam penetration. The maintenance costs for a wooden chamber, however, are likely to be high, and unless the chamber is required for a short period only, it is advisable to build it of concrete. Even then, the walls must be coated regularly, to protect

them against the steam. In practice, boiled linseed oil has been found to provide a good and cheap coating, and an easy one to apply. Further investigation into wall coatings is required.

The size of the chamber will depend on whether it has to accommodate trucks from existing kilns or not. If this factor does not enter, a very good size is 32 feet long by about 6 feet wide by about 6 ft. 6 in. high. This will accommodate trucks carrying timber stacks 5 feet square in cross section. A perfectly plain chamber without any vents is all that is required, but it must be as steam-tight as possible, partly because of steam economy and partly in order that a high temperature may be maintained. A satisfactory door is the most difficult part of the construction. It is necessary to run the timber in on trucks, stripped out as for drying. Complete plans of a suitable chamber will be supplied by the Division of Forest Products, free of charge, on application.

Steam is supplied to the chamber through a pipe at one side or end or through a perforated pipe running the full length of the kiln along the centre of the floor. Either exhaust or live steam may be used, but the supply must be sufficient to maintain the desired temperature. As far as is known, it is advantageous to keep the temperature at 212° F. Steam requirements are greater at the beginning of the treatment than after the timber has been heated through.

The treatment consists simply of running the timber into the chamber, closing the door, and steaming for the required period. The length of the steaming period is dependent on the severity of the collapse, and for this reason badly collapsed stock should, where practicable, be sorted from less severely collapsed stock and treated separately. Determination of the time required is simply a matter of observing the degree of recovery in size obtained.

There is not sufficient information on hand for advice to be given regarding the best treatment to follow the steaming, but on no account should stock be machined as soon as removed from the steaming chamber. For 1-in. stock with a case moisture content of about 13 per cent. to 15 per cent. when removed from the chamber, several days standing racked out under shelter seems to be advantageous. Severely collapsed stock, steamed for a longer period, will probably attain a much higher moisture content and, if so, will require a longer period between steaming and machining. In this case particularly, re-drying in a kiln might be desirable.

As was stated at the beginning of this article, the treatment is not yet perfected, but it has been developed sufficiently to have proved of great value to those millers who have adopted it. The Division of Forest Products is anxious that its adoption should become more widespread, and will be glad to advise and assist any timber man wishing to take up the treatment.

Recent Developments in Blowfly Research.

The article that follows has been contributed by the Council's Division of Economic Entomology. It does not attempt to give an account of the whole of the Division's work with parasites, traps, repellents, &c., but is descriptive of certain fundamental conceptions that relate to the blowfly problem.—Ed.

1. Introduction.

Probably no single problem is regarded by Australian primary producers as of equal importance, and no single source of loss as great, as that caused by blowfly attack in sheep. The actual monetary loss has been assessed by various authors at sums running up to £4,000,000 per annum, and these estimates do not appear to have been unduly high. Putting the matter in a slightly different form, the most recently available figures indicate that approximately 3½ per cent. of the cost of production of wool in Australia is due to the activities of the blowfly. Such a percentage, even if a small one, becomes of great importance to the survival of the industry at times such as the present, when the price received approximates closely to the cost of production, and it is for this reason that the blowfly is a greater menace to the pastoralist to-day than it has ever been in the past, even in the years of its most widespread activity and greatest virulence. The Council has been fully seized with the importance and urgency of the problem, and on the inception of the Division of Economic Entomology, a full investigation of the biology of blowflies and of the possibility of limiting their attack was included as one of the major sections in the programme of researches presented by the Chief of the Division, Dr. R. J. Tillyard, and adopted by the Council.

The present review is largely concerned with the researches which have been undertaken by the Division of Economic Entomology, but results obtained by other workers are also included, since they, too, show that a fresh and more critical outlook on the problem is developing, which should in the near future lead to a much clearer appreciation of its precise nature, and to very material advances in methods of treatment. In its essentials, this new view-point is directed at the blowfly population, and the exact nature and relative importance of the various influences that may affect it. It is no longer sufficient to say that the efficiency of a parasite or trap may be gauged by the number of blowflies it destroys. What is demanded is an indication of its influence on the effective blowfly population at the critical stage in the life history. Nor is it sufficient to say that certain blowflies attack sheep. One must be able to determine which species are primary, i.e., can attack uninjured sheep, and which are dependent on the presence of the primary species for a foothold on the sheep. Briefly, what is required is a knowledge of, firstly, the species primarily and secondarily responsible for blowing living sheep; secondly, the factors influencing blowfly population in general and the population of the

primary species in particular; and, thirdly, the relation of blowfly population to strike in sheep. Given this knowledge, the properties required of a parasite, or any other control method, may be determined and its probable usefulness assessed.

2. The Blowflies Responsible for Strike.

Seven species of flies have been bred from living sheep, but only a few of these can be considered as of major importance. In the earlier investigations, it was believed that the common native brown blowflies (*Calliphora stygia* Fabr. and *C. augur* Fabr.) which are so numerous in houses, were the chief cause of the trouble, and various theories were put forward to explain what appeared to be the development of a new habit by these species at the beginning of the present century, since sheep do not appear to have been attacked at all heavily before the 1901-2 drought. Later, about 1913, the green blowfly which produces hairy maggots (*Chrysomyia rufifacies* Macq.) came into prominence because of its voracious habits and the extensive injuries it inflicts on the sheep. The fact that it devours a great many of the smooth maggots, however, soon attracted attention, and the question of its precise relation to the tissues of the living sheep has recently been the subject of considerable discussion. There is now reason to believe that *C. rufifacies* is purely secondary, and a considerable body of evidence has accumulated in favour of the view that another green species with smooth larvae (*Lucilia sericata* Meig.) is the most important primary blowfly of sheep in Australia.

Before dealing with this question, it might be desirable to indicate briefly the differences between these two important species, in order that those who are not acquainted with the methods of systematic entomology may be able to distinguish them with reasonable accuracy in the field. These, and other blowflies, were excellently illustrated in colour by Froggatt in 1914 (*Agricultural Gazette, New South Wales,* 2nd September, 1914, pp. 756-758; reprinted as Miscellaneous Publication No. 1764 under the title "Sheep Maggot Flies"), and reference to this plate will materially assist in identification. These appear to be the only adequate figures that have been published.

Lucilia sericata Meig.: No bristles on posterior aspect of upper surface of basal section of stem vein of wing. A rather smaller, less robust species. Colour green to brassy with no trace of narrow transverse blue bands adjacent to the lines of junction between the abdominal segments. Larvae rather slender, smooth, creamy in colour, frequently with a tinge of pink.

Chrysomyia rufifacies Macq.: A row of bristles present on the posterior aspect of upper surface of stem vein of wing. A more robust species, with a more rounded head. Colour green to bluish green, with narrow but conspicuous transverse blue band at the line of junction between the segments of the abdomen. Larvae robust, hairy, cannibalistic, grey in colour.

The difference in the bristles on the wing, although only to be seen with the microscope, is included, since it will enable those who possess the necessary equipment to distinguish between the two genera with certainty. At first, the other differences in the adults may be thought too trivial to be of much use, but with a little experience, the species can be easily recognized with the naked eye.

Lucilia sericata is at the present day almost cosmopolitan in its distribution, but it appears practically certain that it was originally an old world species which has gradually been dispersed by the agency of man. The evidence for its importance in Australia may be summarized under the following categories:—

1. Wherever there is a serious blowfly problem *L. sericata* is present and in some areas, e.g., Great Britain, it is the only species that attacks sheep.

2. The history of the development of the blowfly problem in Australia is exactly what would be expected from the increase and spread of an introduced pest. Incidentally, there is no blowfly problem in the Fitzroy River district, Western Australia, where *Lucilia sericata* is at present unknown; and in the Gascoyne district, the onset of serious strike in sheep is said to have dated from the appearance of the "green fly" only three or four years ago.

3. Lucilia was bred from living sheep in the early days of infestation in Queensland and Victoria, and was also soon found in New South Wales. Gurney and Woodhill have recently found that it was present at Moree whenever sheep were struck, and occurred in sheep in higher proportion to general abundance than any other species. The New South Wales External Parasites in Sheep Committee stated, in 1928, that "examinations of crutchings from living sheep indicate that *Lucilia sericata* is the most serious of the flies."

4. The relation of the flies to carrion also throws some light on the question. It is found that Lucilia is the first species to arrive at a carcass and the first to lay its eggs, being stimulated by a very early stage in decomposition. It is reasonable to expect therefore that the fermentative processes which go on in wool, particularly if wet or soiled, would have a greater attraction for this species than for other blowflies. Another observation, which may explain why Lucilia is not bred from sheep in as great numbers as might be expected, is that the Lucilia larvae soon become crowded out by those of the more robust species, and consequently, an examination at a late stage may reveal few or no Lucilia although they were numerous earlier.

The brown blowflies (*Calliphora stygia and C. augur*) have been bred from living sheep in considerable numbers, and occasionally under conditions which clearly show that they may be primary causes of strike. In the very great majority of cases, however, it seems highly probable that the way is cleared for them by Lucilia, and that when present alone they can infest only a very small percentage of a flock.

The problem presented by *Chrysomyia* is much more interesting. It is known to devour other larvae, and some have considered that it was therefore useful, while others believed that it caused more damage to the sheep than to the other blowflies. Experiments with carrion show, firstly, that *C. rufifacies* does not lay its eggs until some change

has been produced in the medium by the Lucilia or Calliphora larvae; and, secondly, that the Chrysomyia larvae only mature normally on a mixed diet of altered tissues and living maggots. Thus, it is clear that while Chrysomyia may damage the sheep, it can only do so in the presence of other species; and consequently control of Lucilia should also automatically solve the hairy maggot problem.

3. Environmental and Population Studies.

If the body of a freshly killed animal, say a cat, is exposed in the field during the warmer months, the first visitor is the green fly, *Lucilia sericata*, which arrives within an hour or two of death and lays its eggs during the first and second days. Other species, including Chrysomyia, may visit the carcass early, but only to feed, not to lay eggs. On the second day, the brown blowflies, *Calliphora stygia* and *C. augur*, are also depositing their eggs or maggots, and by the third or fourth day the carcass is full of smooth larvae, is becoming liquefied, and has a strong and unpleasant odour. Now the second green species, *Chrysomyia rufifacies*, deposits its eggs, which soon hatch, and the vigorous hairy maggots rapidly outgrow the smooth ones, which they devour or drive off the carcass. During the next few days, the larvae, first the smooth and later the hairy ones, are leaving the carcass and seeking a place, usually in the soil underneath, where they can turn into pupae in order to undergo the final metamorphosis into the adult form. The carcass is commencing to dry up, and two other species of flies are now breeding in it. The most numerous is *Peronia rostrata*, a black fly, which is rather smaller than the average blowfly, and the other is *Piophila casei*, the larvae of which are the well known "cheese hoppers." The latter is quite a small species, but its larvae may be sufficiently abundant to effect the destruction of a considerable proportion of the remaining soft tissues. Finally, nothing remains on the skeleton but hair, skin, and gristle, and even these are destroyed by the adults and larvae of the Dermestid beetles, which are the last in the succession of insect inhabitants of the carcass.

The flies and Dermestids are not the only insects which live in carrion. Quite early, several species of beetles arrive, and the majority of these feed on the growing blowfly maggots. They lay their eggs and depart when the maggots are leaving the carcass, and their larvae frequently feed on the blowfly puparia. At a later stage, another beetle, *Necrobia*, shares with Peronia and Piophila the work of completing the destruction of the soft tissues. Parasitic wasps, such as the well-known *Mormoniella vitripennis* (*Nasonia brevicornis*) may arrive quite early, and wait for several days until pupae which they can parasitize are formed.

Thus the process of disintegration of a carcass may be divided into a series of stages, each characterized by its particular group of insect inhabitants, and there is now experimental evidence to show that a given species is only able to thrive during a certain stage of decomposition. Furthermore, there is evidence that the progress of decomposition is profoundly influenced by the insect inhabitants. For example, the particular type of liquefaction which is suitable for the development of *Chrysomyia* normally does not supervene unless the smooth larvae are present. These observations have an important

practical bearing. The environment of the larvae of a particular blowfly, say *Lucilia sericata,* can no longer be considered as any carcass, but only those carcasses in a particular stage of decomposition. If, therefore, one is endeavouring to combat this species by means of carcass destruction or poisoning, attention must be concentrated on carrion in the first and early part of the second stage of decomposition. If treatment is left until later, the bulk of the Lucilia will go free, and the effect will be to discriminate against the Chrysomyia larvae, which are their greatest enemies.

The second and most outstanding phenomenon to be observed is the intense competition for food and space among the blowfly larvae. Lucilia comes first, and at the beginning there is sufficient food for the young larvae. However, by the time the Calliphora are added to the population, and the larvae are growing bigger and requiring more food, the carcass is overcrowded, half-fed larvae are displayed, and many die of starvation. Then come the vigorous, robust, hairy maggots of Chrysomyia, which by their superior size and strength jostle the smooth larvae off the carcass and force them to leave it in thousands to die, or, if they are sufficiently developed, to pupate and emerge as undersized adults. It is impossible to visualize the intensity of this competition unless one has seen it. Actually, the numbers of any one species are more than sufficient during favorable parts of the year to fill the carcass to the limits of its capacity, and we have four species occupying it in rapid succession, the period of each overlapping to a considerable extent that of the others.

The third phenomenon is the action of the natural enemies. Certain beetles devour the eggs and young larvae, other beetles and the Chrysomyia larvae destroy the bigger maggots, and the puparia are attacked by the larvae of the beetles and by various parasitic wasps, of which *Mormoniella* is the most conspicuous. All these agencies greatly reduce the number of emerging flies, yet such is their fertility and capacity to discover their breeding-grounds, that even these depleted numbers can find every breeding place in the country and overcrowd it with their progeny.

From these observations, and particularly from the outstanding fact that there is an intense competition for food and space among blowfly larvae, certain important conclusions may be drawn. In the first place, it may be definitely concluded that the amount of food available for the larvae is the primary factor limiting the abundance of blowflies in this country. The only effect of all the natural enemies and the vicissitudes the adults meet with before laying their eggs is to tend to reduce the intensity of the competition. In no instance is there the slightest indication that these other factors ever reduce the blowflies to a point at which competition no longer occurs, and therefore become themselves the primary factors limiting the abundance of the blowflies. Secondly, from the uniformity with which competition can be observed, it is certain that the blowfly population of the country is greatly in excess of the number that would be required to find and occupy all available carrion. This applies equally to the population of each individual species as to the total blowfly population as a whole. It follows that any attempt to reduce the blowfly population to a point at which the larvae no longer fill their environment must first account for this enormous surplus before

it can have any practical effect. Indeed, the less intense the competition, the larger, more vigorous and more fertile are the emerging blowflies, so that reduction of the population up to a point increases the efficiency of the flies. It is very necessary to bear these considerations in mind when considering the practicability of any control method.

Given the fact that, despite the enormous mortality between the egg and mature adult stages, there still remain more blowflies than would be sufficient to fill the larval environment, the reasons for this state of affairs may be sought. The explanation lies in the fertility of the female fly and its ability to discover situations in which to deposit its eggs. A female *Lucilia sericata* may produce upwards of 1,000 eggs in the course of her life, and these are deposited in several batches. Cousin's work in France showed that the eggs do not mature until about the tenth day of adult life, and that maturity is dependent on the fly having had nitrogenous food during that time, the best results being obtained on a balanced diet of protein and carbohydrate. Thus, the first ten days of life may be regarded as the pre-maturation period, and are spent in seeking suitable food and in ranging over the country from the place of emergence. The remainder of the life, which the work of Gurney and Woodhill and of Johnston and Tiegs shows may be about three weeks in duration, or even longer, is spent in seeking breeding-grounds. Unfortunately, we do not possess any precise data on the distance from which a fly may be attracted to a living sheep, but Gurney and Woodhill's valuable studies on range of flight show that *Chrysomyia* may fly at least 10 miles in 28 days, and the actually effective range of Lucilia is probably not less. Thus the carcass of a sheep may, during the spring and autumn months, produce enough Lucilia effectively to search over an area of about 30 square miles. During these months, the actual concentration of Lucilia, apart from the other species, in eastern New South Wales, is probably of the order of 100,000 to the square mile, so it is not surprising that every available situation for larvae is seized on and fully occupied.

The foregoing statements have been based on what may be termed average climatic conditions. There is actually a great variation in abundance of the various species at different times of the year. Such seasonal fluctuations are usually regarded as chiefly due to the direct influence of the climate on the insect, but the detailed work on the blowflies shows that the effect on the environment is equally as important. During the winter, the first stage of decomposition is greatly prolonged, but *C. stygia* is the only species that is able to take advantage of this, the others hibernating either as fully-fed larvae or as pupae. During spring and autumn, the first stage is still of fair duration and Lucilia, which has by now become active, can take full advantage of the favorable conditions. As the weather becomes warmer, conditions favorable to Lucilia become more limited in duration, and at the same time Chrysomyia appears in numbers, the whole environment becoming increasingly unfavorable to the smooth maggots. It is not necessary to go fully into this question here, but it is clear that an adequate explanation can be given in terms of variation of the environment of the double seasonal wave of *Lucilia sericata* found by Gurney and Woodhill.

4. The Relation of Fly Population to Strike in Sheep.

It has been indicated above that the larval environment, as represented by carrion, is grossly overcrowded under natural conditions in Australia. It has also been indicated that the population of adult blowflies is a great deal more than sufficient to find and occupy fully every available breeding-ground. What effect has this on strike in sheep, and what diminution in population is necessary before the incidence of strike is influenced?

In the first place, it must be remembered that the sheep forms part of the larval environment and the incidence of strike is therefore to some extent at least dependent on the relation of the larval population to the whole larval environment. However, there may be a difference in attractiveness to the fly between carrion and sheep and between sheep of different breeds and in different states of health, and this may affect the incidence of strike. Essentially, these differences in attractiveness may be measured in terms of the distance over which the attraction operates. If a carcass will attract blowflies over a radius of 50 feet, and a sheep over a radius of 10 feet, there is a much greater chance of the former being found by flies which are ranging over the country in search of breeding-grounds. Unfortunately, there is as yet no practical index of relative attractiveness available, and it is necessary to draw one's conclusions from inference.

Either one may assume the sheep is more attractive, of the same attractiveness, or less attractive to the fly, than is carrion. If it is more attractive than carrion, then every sheep would be struck and all suitable parts of the surface would be more overcrowded with larvae than would a carcass exposed in nature. Similarly, if the attractiveness were equal, every sheep would be overcrowded to the same extent as the carrion. Neither of these things happen in nature, and it is only possible to conclude that a proportion of the sheep are quite unattractive to the fly, while the remainder vary in attractiveness from a slight degree, when only a very few larvae are found, to a degree of the same order as that of carrion when strike is found to be very heavy. This conclusion is favoured by field observation. Furthermore, a sheep may be susceptible at one time and not at another, and a fair knowledge is being acquired of the factors which predispose to attack.

Given, then, that the sheep is less attractive than the carcass, what follows? At the present time in Australia, there is certainly a sufficient population of *Lucilia sericata* to strike every susceptible sheep, no matter how slight its susceptibility. If the blowfly population be gradually reduced, competition becomes less intense, but reduction must go on until either competition is entirely eliminated or, which amounts almost to the same thing, the emerging flies are so few as to be insufficient to find every possible breeding ground before the incidence of strike is affected. In a word, a great proportion of the surplus blowflies must be destroyed, the proportion bearing a relation to the relative attractiveness of the two larval environments. The problem, therefore, is not like that presented by the blowfly nuisance in houses, since a small percentage of destruction does not bring a corresponding degree of relief—in fact, it brings no relief at all. The surplus must be destroyed and then appreciable benefit will be felt. It is this fact that renders blowfly control work so difficult. Any controlling agent, whether natural enemy, trap, destruction of carcass, or whatever it

may be, must alter the relation of the larval population to the larval environment, and in fact must itself become the primary cause of the limitation of the blowfly population before it can be expected to be of real economic value, and agents of such efficiency are difficult to find.

5. Conclusion.

The quest for a means of effecting an adequate control of the blowfly population is by no means a hopeless one, but it involves slow and laborious investigations, and where so many able workers have failed in the past, it cannot be expected that immediate spectacular results will be achieved. While awaiting this desirable end, however, it is not necessary to sit down and bear the loss. If the fly population cannot be adequately controlled, a great deal can be done to protect the sheep from its attack, and a wide field of useful work lies here in which the animal breeder, the physiologist, the veterinarian, the chemist, and the entomologist, can co-operate with undoubted benefit to Australia's most important industry.

White Ant Investigations in the Federal Capital Territory.

By G. F. Hill, Senior Entomologist, Division of Economic Entomology.

In a previous issue of the *Journal* (Vol. 2, No. 3, p. 178), reference was made to proposed investigations on termites (white ants) by the Division of Economic Entomology, in collaboration with the Division of Forests Products. These investigations are now in progress, and the results to date indicate an increasingly wide field for research of economic value.

1. Field Investigations.

Although the Federal Capital Territory is not an ideal area in which to carry out field researches, investigations have shown that its termite fauna comprises about thirteen species, of which at least five or six are of definite importance in relation to the destruction of growing forest trees, wooden buildings, fencing posts, grassland, &c. Of these, the most important is a widely distributed species of *Eutermes* (*E. exitiosus*), which causes considerable damage to timber structures generally. Service tests with this termite on 206 specimens of 44 species of Australian timbers (identified and supplied by the Commonwealth Forestry Bureau) have been initiated in the Black Mountain Forest Reserve and in the Cotter River Catchment Area. In addition to these, a set of 130 specimens of pine, specially prepared by the Forest Products Laboratory, Madison, U.S.A., are under test with *Eutermes* and *Coptotermes* in the same localities. It is of particular interest to note that this set is one of four which were prepared for testing in various parts of the world, and that the three remaining sets are now under observation in the Panama Canal Zone, Hawaii, and South Africa respectively. The results of these international tests, with a wide range of termites under various conditions, are expected to give valuable data in arriving at standard methods of wood preservation.

Tests are also being made of certain extracts from resistant woods, involving the setting out of 168 specimens, and of various supposed preservative treatments, involving an additional 30 specimens.

A series of practical field tests are being made, in collaboration with the Department of Home Affairs, Federal Capital Territory Branch, to determine the value of a simple and inexpensive method of protecting fence posts, house blocks, &c., from termite damage. In all, 317 posts, representing four species of local timber, are under observation in two localities.

In nearly all cases, the smaller specimens have been placed in or near the termites' mounds and are being subjected to a severe test. Some difficulty has been experienced in finding entirely satisfactory sites for these experiments, notwithstanding the fact that two closely-guarded areas have been made available in which forest overseers exercise a general supervision over the movements of persons entering them and are watchful for outbreaks of fire. Apart from the risk of loss of specimens by forest fires and interference by mischievous and inquisitive persons, considerable time is spent in routine inspections by officers of the Division owing to the necessarily scattered distribution

of the testing mounds. In order to overcome these disabilities, it was decided to attempt the establishment of a field test plot adjacent to the Black Mountain Forest Reserve, that has been set aside for the Council's purposes. With this object in view, ½ acre of land, partly covered with eucalyptus trees and scrub, was securely fenced, and into it were brought, in January and May last, 84 fully-occupied mounds of *Eutermes exitiosus,* which were set out in rows 10 feet apart each way. Within a few weeks of their transfer these colonies appeared to have become established in their new surroundings, as evidenced by a general attack on wood debris, fence posts, and the bark of living trees in the vicinity; and, at the time of writing, a number of tests are in progress in heavily-infested soil. Should this novel method of forming an artificial testing plot prove successful it will be possible to carry out an almost unlimited number of service tests with this species of termite under practically natural conditions and at minimum cost in time and labour. Owing to the large size and construction of their mounds, it appears very improbable that a similar testing plot can be established with species of *Coptotermes,* the next most important group found in the Territory.

2. Tests with Laboratory Colonies.

Difficulty has been experienced here, as elsewhere, in devising means of maintaining laboratory colonies of termites, and in all cases attempts with *Coptotermes* have failed, although a considerable degree of success has been achieved with other genera. In the case of *Eutermes exitiosus,* methods have been so far perfected that uninterrupted feeding tests on treated and untreated wood and other materials have been in progress for several months past.

The container found to be most satisfactory for laboratory colonies is a wide-mouthed, cylindrical, glass preserving jar with a metal screw top and a capacity of 1 quart. These are taken to a populous mound and about half filled with the woody, honeycomb, material from the interior of the structure, with the addition of a smaller proportion of the earthy matter composing the outer walls. The material thus collected usually contains a sufficient number of termites to stock the jars; if not, additional insects are gathered up with nest debris and added. The proportion of larval forms varies according to the season of the year, but so long as such a jar appears to contain a preponderance of adult workers, which can be provided for by selecting material from suitable parts of the mound, the former are disregarded, because it is they who perish first in captivity. Since it has not been ascertained at what stage of its development the young termite begins to feed itself, and since it is practically impossible to eliminate all adolescents, no attempt has been made to determine approximately the number of insects to be used in the foundation of such laboratory colony; in practice, however, it has been found that very small colonies give unsatisfactory results, whilst very large ones die out rapidly, presumably from overcrowding. When stocked as above the lids are screwed down tightly and the jars are removed to the laboratory, where they are placed in an underground chamber in which the temperature and humidity can be regulated. Wood or other material to be fed to the termites is inserted in the jars, which are again closed tightly and kept so, excepting only while inspections are being made. The construction of a new termitarium, which will ultimately occupy the entire space

of the jar, and an attack on the material to be tested, if it be non-poisonous or non-resistant, commences forthwith. The optimum conditions as to temperature and humidity remain to be determined, but these would appear to be in the vicinity of 75° F. and 50 per cent. respectively.

Small colonies as described above have been maintained in active conditions for periods of up to six months, but the average period is much lower, due to various little-known circumstances, but often due to excessive or insufficient moisture in the jars. In the former case, predacious mites almost invariably make their appearance and seem to hasten the extinction of the colony. It has been noted that whilst it is generally believed that the soldiers and nymphs (young of the winged adults after the first appearance of wing buds) are incapable of feeding themselves and are entirely dependent for their food upon material prepared by the workers, these forms survive in a dwindling colony long after the latter have perished.

For the purpose of carrying out laboratory tests, it has been found more satisfactory to employ a colony for only one series of experiments, after which it is discarded unless it be desired to keep it under further observation for some particular purpose, in which case further feeding is generally confined to a diet of pure wood cellulose, upon which substance termites appear to be capable of sustaining themselves for an indefinite period.

It is impossible to indicate, at this stage, how far this phase of the investigation is capable of expansion, but it can be stated that data of practical value have already been obtained, and that there is every indication that other data of fundamental importance in devising methods of control will result.

It has been possible, following this work, to prepare a provisional list of commonly-used timbers, arranged according to their resistance or susceptibility to termite damage; and this information has been made available already to users of local material. When these results have been more completely checked up with service tests in the field test plot referred to above and the investigations have been extended to include a wider range of commonly-used timbers and a wider range of economically-important termites, the information should be of considerable practical value in the selection of timber for such purposes as telephone poles, fence posts, &c., particularly if it be accompanied by accurate information as to the distribution of termite species.

A feature of these laboratory tests has been the marked reduction in the time required to obtain definite data, as shown by the fact that the wood specimens which were used in them and which were satisfactorily tested in from 17 to 22 days, were cut from larger specimens which in most cases had survived nine months' exposure to attack in mounds of the same species.

There would appear to be no practical difficulty in carrying out laboratory tests in much larger containers, and with larger colonies and many more wood specimens than those used hitherto, thus reducing the time spent in the preparation of, and observation on, individual colonies and providing simultaneously a wider choice of food material.

That these laboratory tests, in which definite results are obtained within a period of less than three weeks, are not in the nature of "starvation tests" is evidenced by the fact that similar colonies, when

provided with loam from adjacent grazing land or with material from the original termitarium only, survived for periods of over 21 days and 81 days respectively.

Up to the present, attempts to maintain laboratory colonies of *Coptotermes lacteus* Frogg. and *C. flavus* Hill have not met with much success, but another economic species, *Heterotermes ferox* Frogg., appears to be more adaptable, though as yet not available for duplicating the tests which have been, and are being, carried out with *Eutermes exitiosus*.

Attempts are now being made to establish in the laboratory some of the more destructive northern species, particularly *Mastotermes*. Should success be achieved, it will be possible to carry out many preliminary tests which are not otherwise practicable under present circumstances.

3. White Ants in Growing Timber.

The Inspector-General of Forests, Mr. C. E. Lane Poole, has recently drawn attention to the enormous destruction of the best classes of timber in the principal forests of Victoria and New South Wales, and has expressed the opinion that the same factors are probably operating in the more limited forest areas of the Federal Capital Territory. The growing conviction that termites play a far more important rôle in this connexion than is generally believed led the Division to carry out some preliminary investigations in the mountainous country near the eastern boundary of the Territory, with the result that termites (*Porotermes adamsoni*) have been implicated definitely as one of the principal primary causes of destruction of otherwise normally healthy trees. Still more recently, and as a result of conversations with other forestry authorities, a brief inquiry was made in one of the largest forest areas in Gippsland, where evidence was obtained of immense damage by termites (*Calotermes insularis*) to all of the best commercial timbers. Neither of these insects have been recorded hitherto as destroying living forest trees, though both are common and widely distributed in south-eastern Australia.

That much of this continuous drain in our rapidly diminishing timber resources is preventable, would appear to be reasonably certain; the problem, however, is one for co-operative investigation by entomologists and forestry experts.

4. Determination of Species.

The importance of correct determination of species is becoming more widely recognized, resulting in an increasing use by Commonwealth and State organizations, and others, of the unrivalled reference collections at the disposal of the Division. During the past few months, several extensive collections have been received for identification, and over 400 determinations have been made, apart from those required by the Division. In studying this material, much valuable information has been obtained on the habits and distribution of economic species. Further, considerable collections and much additional information have been gathered by officers of the Division in the course of field trips to various localities within and beyond the Territory. The need for taxonomic studies in this group of insects is evident from the fact that a very large and rapidly increasing number of termites are still unnamed

and undescribed, leading to much confusion and difficulty in keeping accurate records.

That interest is being taken in the efforts of the Council to devise means of minimizing termite damage is evidenced by the number of inquiries which have been received from various sources. In some cases it has been possible to give the desired information and advice; in many others, however, lack of essential knowledge has restricted assistance to mere suggestions; for instance, very little is known of the identity and habits of species which cause damage to subterranean telephone cables, beyond the fact that *Mastotermes darwiniensis,* the largest and the most destructive of all Australian species, has been definitely implicated in two instances in North Queensland. Reports have been received of similar destruction in New South Wales and South Australia, clearly the work of some other species, since *Mastotermes* does not exist in either of these States. Reported serious damage to indigenous pastures in New South Wales is almost certainly the work of a species of *Hamitermes,* the majority of which group feed exclusively on grass and other herbage. Few architects and builders appreciate the risks of termite damage to buildings, and, in neglecting to take adequate precautions, often involve their clients in considerable loss and inconvenience. Such cases have occurred recently in Adelaide, where the wood flooring and joists of a modern steel and concrete building have become seriously infested by an undetermined species of *Coptotermes;* and in Mildura, where termites found access to boxes of dried fruits through cracks in the concrete floor. Such cases as these are extremely difficult to deal with, and such control measures as can be suggested from our present knowledge are generally regarded as being economically and practically impossible.

5. Possible Methods of Control.

The growing demand for control of pests by biological methods, i.e., the use of parasites and predators, has been suggested as a simple and inexpensive means of eradicating termites; but it might be stated quite definitely that, whilst this field of investigation is not being overlooked, the possibility of ever obtaining relief in this direction is extremely remote. It is considered that eradication or reduction to negligible numbers is a practical impossibility, and that the solution of the problem of termite damage lies in the adoption of effective preventive measures in building construction, wood preservation methods, possibly soil poisoning, and such other chemical and mechanical methods as are required to meet particular cases.

Electrical Research in Great Britain—The British Electrical and Allied Industries Research Association.

(Prepared largely from notes kindly supplied by the Association.)

1. General.

Shortly after its formation in the year 1915, the British Department of Scientific and Industrial Research gave a considerable amount of attention to the encouragement of the formation by different industries of co-operative Research Associations, each of which was to engage on investigations likely to be of value to the particular industry concerned. The Government had previously placed a fund of £1,000,000 at the disposal of the Department to enable it to encourage the industries to undertake research.

At the time, however, co-operative research in industry was an experiment, the result of which no one could accurately foresee. Nevertheless between 20 and 30 Research Associations covering various industries were soon formed, and they have been at work with varying degrees of success ever since. They covered such industries as those concerned with electricity, photography, wool, cotton, motor cars, boots, iron, linen, rubber, confectionery, non-ferrous metals, refractories, shale oil, leather, cutlery, laundering, &c.

The method adopted by the Department to encourage the Associations was quite simple and consisted mainly of providing the Association with grants generally on a £1 for £1 basis over an initial period of five years. The Associations are entirely self-governing, and each settles its own programme of researches in relation to its own needs.

As to the results obtained, the following extracts from recent annual reports of the Department are of interest:—

"Now the series of visits has been completed, we are left with the definite conviction that the cumulative effect of the work of the Associations is having, or is likely to have, a profound influence on British industry."

"British industry is learning that it is easier to compete with foreign manufactures if there is co-operation at home than if there is internecine strife, and that there are many technical problems of wide interest and importance which can be attacked more efficiently by a team of workers than by a series of isolated individuals. It is learning, too, that the support of co-operative research does not mean the suppression of individual enterprise; we note with interest how often the strongest support of Research Associations comes from firms which have large research laboratories of their own. This change of attitude is taking place in a period of considerable financial difficulty which prevents its effect being more noticeable."

The British Electrical and Allied Industries Research Association has been one of the most successful of the organizations under discussion.

2. Origin and Objects of the Association (for the Electrical Industries).

This particular Association was founded in 1920 to take over and develop the important co-operative research work being conducted by the Institution of Electrical Engineers and the British Electrical and Allied Manufacturers Association with the assistance of the Department of Scientific and Industrial Research.

The main objects of the Electrical Research Association may be briefly summarized thus:—

(*a*) To investigate matters affecting the proper utilization of plant, apparatus, and materials, with a view to greater reliability in operation and extension of useful life of such plant, leading to a reduction in the cost of electricity.

(*b*) To investigate materials and methods used in the manufacture of electrical plant and apparatus, to develop improved and simplified methods of test for ensuring that materials reach a proper standard, and so secure the establishment of standards for performance which can be relied on by the manufacturers and users of plant and apparatus.

It will be seen, therefore, that the investigations carried out by the Association benefit not only the makers of electrical machinery, but all who use it, and not least those who supply electricity to the public.

The Association has recently been reconstituted somewhat, in the direction of giving suppliers and consumers of electrical energy a fuller share than they had previously had in the control of the researches, and also adequate representation on the Council of the Association. This action was taken largely as a result of a Conference held early in 1929 and attended by representatives of the principal sections of the industry interested in the development and use of electricity. It was also agreed by the Conference that the results already achieved were of great importance to the industry and to the nation, and that it was necessary to stabilize the future income of the Association by broadening the basis of support so as to secure its present scale of expenditure of £25,000 per annum, and, if possible, to extend it. Efforts in this direction are now being made.

3. Results Obtained by the Association.

The value of the benefits gained through the activities of the Association can be reasonably estimated at a figure approaching £1,000,000 per annum. This has been accomplished at a total cost of, roughly, £150,000, whilst the present annual expenditure is about £25,000.

During the time the Association has been in existence, 76 Committees have been formed, on which about 300 individuals have gratuitously given their time and expert knowledge; and, as a result of the researches planned by them and carried out at the National Physical Laboratory and in laboratories of manufacturers and Universities, about 200 reports on researches have been issued to members, of which 46 have been published.

These reports fall into various categories, and there has been a tendency to assess their value as attaching to—

(*a*) manufacturers,

(*b*) suppliers of electricity,

(*c*) consumers of electricity,

and in this way to take a very narrow view of the research and its benefits to individual classes of the supporters of the Association.

There is, however, a much wider view, namely, that the use of electricity has really only one limitation, viz., cost. If the cost can be reduced there is hardly any limit yet in sight, and therefore anything that will contribute towards a reduction of cost will first of all benefit the suppliers of electricity, then the consumers, and then the manufacturers. The true test, then, of the work of the Association is, has it made a real contribution towards the reduction of the cost of electricity supply and can it do so in the future?

As the cost of supply depends on (*a*) the capital cost, (*b*) the running cost, and (*c*) the maintenance, the work of the Association may be considered under these heads. Typical examples are quoted below:—

(a) *Saving on Capital Costs*—

Buried Cables.—Up to 1923, when the Association published its report on the heating of buried cables, there was no exact information available as to the load which cables buried in the streets would safely carry—many cables were capable of carrying much more than the load then on them, but to an unknown extent. It was clear from damage occurring due to overheating that others were being overloaded, again by an unknown extent. At that period, the great expansion of electricity consumption was commencing, and the information needed was vital. The result of the publication of the reports referred to was to put into the hands of the Electricity Supply Authorities exact knowledge of the possible loadings, and as these loadings in general were higher than those in use at the time, it is a reasonable estimate to say that taking the increased loading possible with safety and the decrease of damage in cases where loading was getting too great, a benefit of 10 per cent. on all underground cables was assured to the owners. It was calculated that this increased value was at least £4,000,000 in capital value. Similarly, the beneficial effect on the annual outlay on new cables to the value of, say, £2,500,000 would be £250,000 per annum.

Overhead Transmission Lines.—From the British Electricity Commissioners' statistics, the approximate expenditure on overhead transmission lines in 1925-6 was £1,500,000. The schemes of the Commissioners involve an expenditure of about £10,000,000, to be spread probably over three or four years, so that it is not unlikely that for some years to come the annual expenditure under schemes "adopted" by the Central Electricity Board (including schemes not yet formally adopted) will amount to about £3,000,000 per annum. Careful estimates show that the work of the Association has been responsible for a reduction in the cost of the order of 10 per cent. on the total, thus representing a saving of at least £300,000 per annum in the next few years.

(b) *Saving on Running Expenses*—

Insulating Oils.—During the last ten years, the Association has carried out a series of investigations into insulating oils. As a result of the earlier work, a British Standard Specification was issued in 1923 which incorporated the methods of test recommended by the Association and gave the industry for the first time a definite standard to which

insulating oils having the requisite properties could be purchased. As the result of further work, a revised standard specification was issued in 1927 incorporating still better figures. Consequently, the oil industry is now in a position to produce, and the electrical industry to purchase, oils of the requisite standard at a reasonable price, and the oils now in use are much more reliable in service, principally owing to the greatly reduced tendency to sludge. The expense of continual cleaning and renewal of oil used in transformers has been considerably lessened, and it is estimated that the direct and indirect benefits represent a saving to the industry of at least £100,000 per annum.

Nozzles for Steam Turbines.—Since 1922 (in co-operation with the Institution of Mechanical Engineers), researches have been conducted on the best form of nozzles for steam turbines. As a result, the efficiency of the discharge has been increased by 3 per cent., which is equivalent to a saving of 190,000 tons of coal per annum on the present output of electricity in Great Britain. This represents a benefit to the supply authorities or the consumers of £140,000 per annum, the larger part of which has already accrued.

(c) *Savings on Maintenance—*

It is estimated that maintenance and repairs due to breakdown of insulation are costing supply authorities and consumers of electricity in Great Britain at least £1,000,000 per annum. A much larger sum would be involved were it not for the work already done by the Association. It is not too much to say that in seven years it has revolutionized not only the practice, but even the ideas as to insulating materials. But it is safe to say that much more might be done, and if we may claim that the above sum would be 50 per cent. greater but for the work already done, in other words some £500,000 has been saved, still another such sum remains to be reaped.

These figures seem so large as to be possibly deemed an exaggeration, but it must be pointed out that usually failure of insulation costing a few shillings is followed by burn-outs, stoppages, and consequential damages far exceeding the cost of the materials themselves.

4. Constitution of Association and Possibilities of Participation by Australian Interests.

It has been pointed out previously that each of the various Associations formed largely at the instigation of the British Department manages its own affairs entirely. As a result, the rules of the Association vary somewhat, and membership to some of them is open to Dominion firms outside Great Britain, whereas in other cases it is not. The Research Association for the Electrical and Allied Industries, however, would welcome new Australian members, and in view of the benefits to be obtained by joining the Association, commercial interests in this country connected with the electrical industry, and particularly the electrical supply companies, might well give serious consideration to their joining the Association. The Association's publications are made available to members only, and thus it is only through membership that any particular concern is enabled to reap the advantage of the work being done. Those interested could obtain any further information they might desire regarding the Association by direct application to its head-quarters, 36 Kingsway, London, W.C. 2.

The Value of Aerial Photography in relation to Soil Surveys and Classification.

By Professor J. A. Prescott, M.Sc., and J. K. Taylor, B.A., M.Sc.†*

During the progress of a soil survey of the Renmark irrigation settlement, considerable use has been made of aerial photographs obtained by No. 1 Squadron of the Royal Australian Air Force during October, 1928. The close correlation between soil type and crop vigour which had been established during the survey of Block E and Ral Ral[1] suggested that the boundaries of the soil types could be mapped to some extent from the photographic data. Complications are naturally introduced by factors such as salinity, which is not necessarily restricted to any soil type; by replantings; and, in older-established areas, by soil improvement due to drainage, the use of gypsum, and the ploughing in of green manures.

In the case of the extension of the survey to the older Renmark settlement, there was the further value that no accurate maps were in existence on a scale suitable for soil survey, and the aerial photographs enabled the necessary data to be obtained for this purpose, together with an accurate record of the type, area, and regularity of the cropping.

The photographs were taken from a height of approximately 6,500 feet. One example of these records is given in Figure 1 (see plates), which represents an area of 389 acres of relatively untouched virgin country carrying a vegetation association of box, *Eucalyptus largiflorens;* saltbush, *Atriplex spp.*[2]; bluebush, *Kochia spp.*[3]; samphire, *Pachycornia triandra;* and some annual grasses. The photographs have proved ideal as a basis for soil survey, and it was found possible accurately to fix the position of any soil boring to within 2 feet on the ground and to record the locality on the photograph by means of a pin prick. A close relationship was found to exist between the vegetation associations and the soil types.

In using the photographs as a basis for soil survey, it was found most useful to record thereon at each point where the soil boring was examined the number of the soil type, these numbers having the same significance as those allotted to the Renmark soil types previously described. These types may be briefly described as follows:—

Type 1.—Light textured throughout, red sandy profile to 6 feet; no gypsum, much calcium carbonate.

Type 3.—Fairly light soil, passing to drift sand at 4 feet; no gypsum.

Type 3v.—Somewhat lighter than 3, and with more calcium carbonate.

Type 3A.—Similar to 3, but with heavier subsoils.

Type 5.—Heavier than 3, but otherwise similar; gypsum in subsoil.

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† Soil Survey Officer, Division of Soils.

(1) J. K. Taylor and H. N. England, C.S.I.R. Bull. 42, 1929.
(2) Including *A. paludosum, A. leptocarpum, A. halimoides.*
(3) Including *K. brevifolia, K. tomentosa, K. pyramidata* and *K. triptera.*

Type 5A.—Heavier surface; gypsum in large amounts in subsoil.

Type 5B.—Lighter surface; gypsum at a greater depth than in 5.

Type 6.—Heavy clay; large amounts of gypsum, beginning at 3 to 4 feet; sandy drift deep if present.

Type 6A.—Similar to 6, possibly heavier; gypsum horizon closer to surface.

In Fig. 3 is given a key-plan of the soil borings and vegetation associations obtained during a field examination of the area illustrated in Fig. 1, while the soil-map prepared after a consideration of these observations is given in Fig. 2.

Bluebush without box was found to be associated with a light variety of type 3 soil, with rather more calcium carbonate in the subsoil than one normally associates with the type; for this reason, the term 3v has been used. Box alone or with saltbush, and sometimes saltbush alone, were associated with a typical type 3 soil. Of the type 5 soil, three sub-types were observed depending on the depth to a gypsum horizon, the 5A representing the shallower gypsum and 5B the deeper gypsum. In two or three instances, type 6A was recorded in the borings, but, in the light of other information available, it was presumed that these were cases of type 5A with the underlying sand drift at a somewhat greater depth than usual. Such isolated cases have therefore been treated as sub-types of 5. Type 5A was found to be associated with samphire and saltbush, and where samphire alone was observed, the surface soil was of poor texture. The dark patches to be noted in Fig. 1 are associated with a sandy surface of reddish colour, while the lighter patches are usually wind-swept—where such occurred in considerable areas they were generally found to be of type 5A, but where localized and in association with saltbush or bluebush were more frequently of type 3. Where samphire was found associated with box, these latter were invariably stunted. The general character of the vegetation, as seen on the ground, is indicated in Fig. 4.

In other photographs, and in particular one representing 438 acres of a planted section of Block E, a close relationship was observed to exist between certain soil types and the character of the vines as photographed, and notably the regularity of establishment obtained on soils of type 3. This particular photograph has proved impracticable to reproduce owing to the individual vines photographing as minute dots from the height of 6,500 feet mentioned, and thus nullifying the effect of even the finest screens used in the block-making process. The original, however, shows up quite well the non-planted sand hills of type 1, and the irregularity of crop establishment on types 6 and 6A.

Summary.

Aerial photography has proved of value during the soil survey of the Renmark irrigation settlement in the revision of the existing maps, in the accurate recording of the types, areas and regularity of cropping, and in the mapping of associations of native vegetation, which have been shown to be closely correlated with established soil types.

Entomological Control of St. John's Wort—First Liberations of Chrysomela Beetles.

(From Notes contributed by Dr. R. J. Tillyard, Chief of the Division of Economic Entomology.)

Dr. Tillyard, Chief of the Division of Economic Entomology, and Mr. G. A. Currie, Senior Entomologist, Noxious Weeds Control Section, left Canberra on 20th October to undertake the first liberations of the three species of *Chrysomela* beetles which feed on St. John's wort. The first place visited was Tumbarumba, N.S.W., near which town, on the Mannus Estate, there is a very dense infestation of about 5,000 acres of the weed. The visitors were afforded valuable assistance by the Shire President, Mr. J. L. Thomson; the Shire Clerk, Mr. K. Holm; the Health Inspector, Mr. T. C. Morrow; and the District Forester, Mr. G. Boyd, all of whom showed keen interest in the work. Suitable spots having been selected in forestry reserves near Mannus, two liberations were made on the morning of 21st October, as follow:—

Colony.	Species.	Numbers.	
		Adults.	Larvae.
V.1. ..	*Chrysomela varians* ..	480 ..	(see note)
D.I. ..	*Chrysomela didymata* ..	— ..	180

It was also arranged with Mr. Boyd that he would visit and report on the progress of the new colonies, and would receive and place out further colonies as more beetles become available.

The following day, 22nd October, was spent in travelling from Tumbarumba via Albury to Myrtleford, where the visitors were met by Mr. J. Matthams, Superintendent, Mr. E. J. Pemberton, Chief Inspector, Mr. W. B. Tiernan, Local Inspector under the Vermin and Weeds Act; Mr. J. F. Stubbs, President of the Progress Association; Cr. Vincent, President of the Bright Shire Council; Mr. D. Ingle, Commissioner of Forests; and Mr. T. Macguire, Inspector of Forests.

Early the following morning, a liberation was made in a closed forestry reserve near Myrtleford, and in the afternoon two liberations were made in other forestry reserves close to Bright (Porepunkah), in spots selected by Mr. Currie.

The following is a list of the liberations made in the Bright and Myrtleford district:—

Colony.	Species.	Numbers.	
		Adults.	Larvae.
V.2. (Myrtleford)	*Chrysomela varians* ..	608 ..	(see note)
D.2. (Bright)	*Chrysomela didymata* ..	60 ..	270
H.1. (Bright)	*Chrysomela hyperici* ..	120 ..	—

Note.—Large numbers of young larvae deposited by the adults during transit in the jars from Canberra were liberated with these, but the exact number was not counted.

It is necessary to emphasize the fact that the work with *Chrysomela* is quite in the experimental stage, and that some time must elapse before it will be possible to judge the actual value of the beetles in the field. As to the insects themselves, *Chrysomela varians*, the smallest species, is peculiar in depositing larvae instead of eggs. This enables it to move along more rapidly than the other species, and at present it is the most

promising of all. The other two species, *Ch. didymata* and *Ch. hyperici*, both lay eggs which take from eight to ten days or more to hatch, but they are larger insects than *Ch. varians*, and *Ch. didymata* in particular appears to be very voracious. The average number of eggs or larvae laid by a single fertile female of either species is about 1,000, so that the increase is five hundredfold per generation, allowing for 50 per cent. of males. The average period from egg or larva to adult in summer weather is about six weeks, so that, assuming that there are three generations in one year, the possible total increase would be 500 x 500 x 500, or 125 million. Some will be killed off by accidents, particularly in the pupal stage, and others by spiders or predatory insects, but if no specific predator or parasite appears that confines itself to attacking the beetles only, the rate of increase should certainly be very great.

It is hoped to make further liberations during the coming summer, and perhaps by the end of that season it may be possible to judge the capacity of the beetles for spreading and for damaging the weed. Should the present liberations develop, under the care of officers of the State Forests Commission, into large colonies, it will be possible to use them as sources of supply to the owners of adjacent holdings.

In all localities visited during the liberations that have already been made, the local residents were keenly interested. It was made perfectly clear to them, however, that the liberations were entirely experimental ones, and that it would be most unwise to expect too much from the beetles at the present stage, or to slacken up with the present work of prevention of the spread of the wort by chemical agents, such as salt.

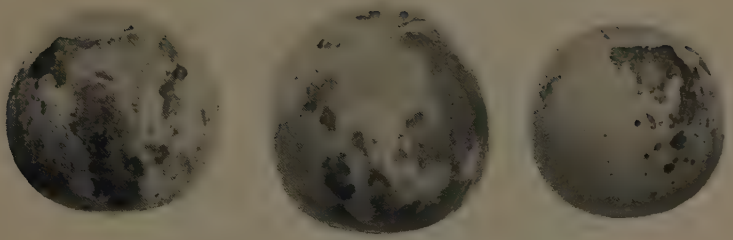

FIG. 1.—Superficial Scald on Granny Smith apples.

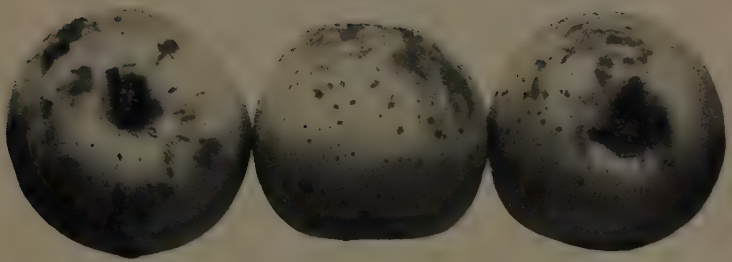

FIG. 2.—Lenticel Scald on Granny Smith apples.

FIG. 3.—Jonathan Spot on Jonathan apples.

To face page 232.

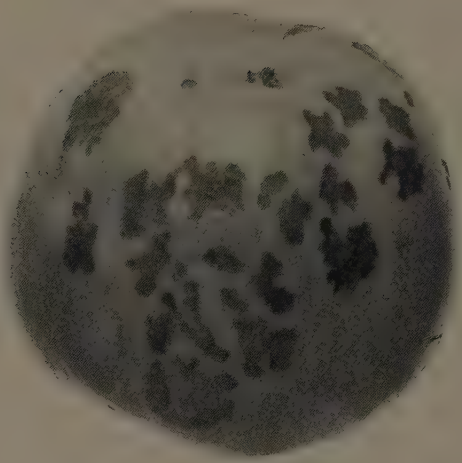

FIG. 4.—Lenticel Blotch on Jonathan apple.

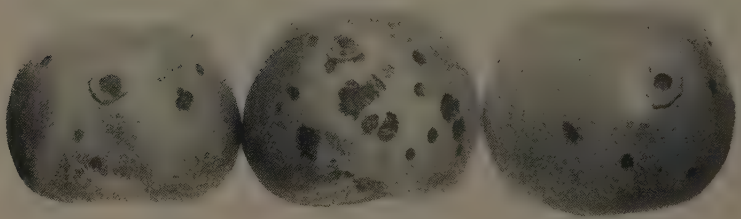

FIG. 5.—Lenticel Blotch on Jonathan apples.

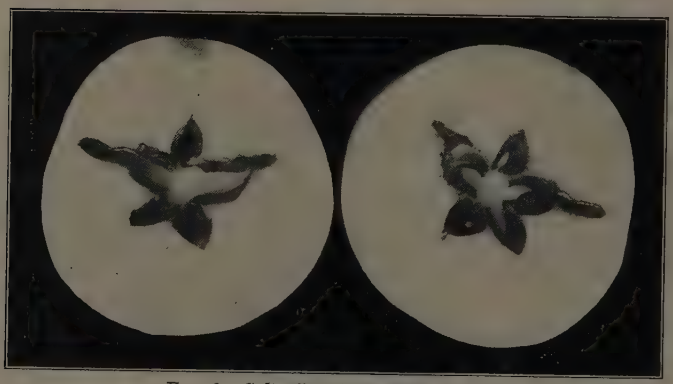

FIG. 6.—Split Core in Cleopatra apple.

PLATE 3.

FIG. 1.—End view of three collapsed boards, showing different types of irregularity.

FIG. 2.—Pieces of collapsed mountain ash boards paired with pieces from corresponding boards after reconditioning and redrying to approximately the same moisture content.

Blocks kindly lent by Forests Commission of Victoria.]

FIG. 3.—Surface view of collapsed board shown in end view on right hand side of Fig. 1. This type of irregularity is known commonly as washboarding or corrugation.

Block kindly lent by Forests Commission of Victoria.]

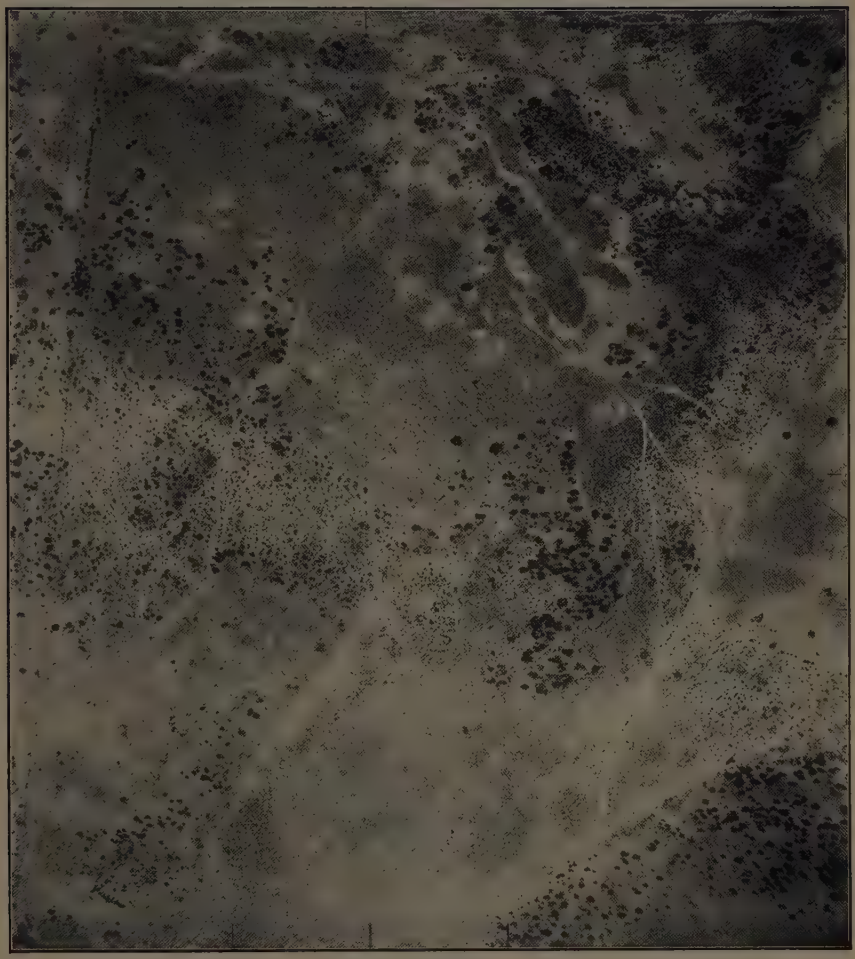

FIG. 1.—Aerial photograph of virgin country in Renmark district: area approximately 389 acres. Taken from 6,500 feet.

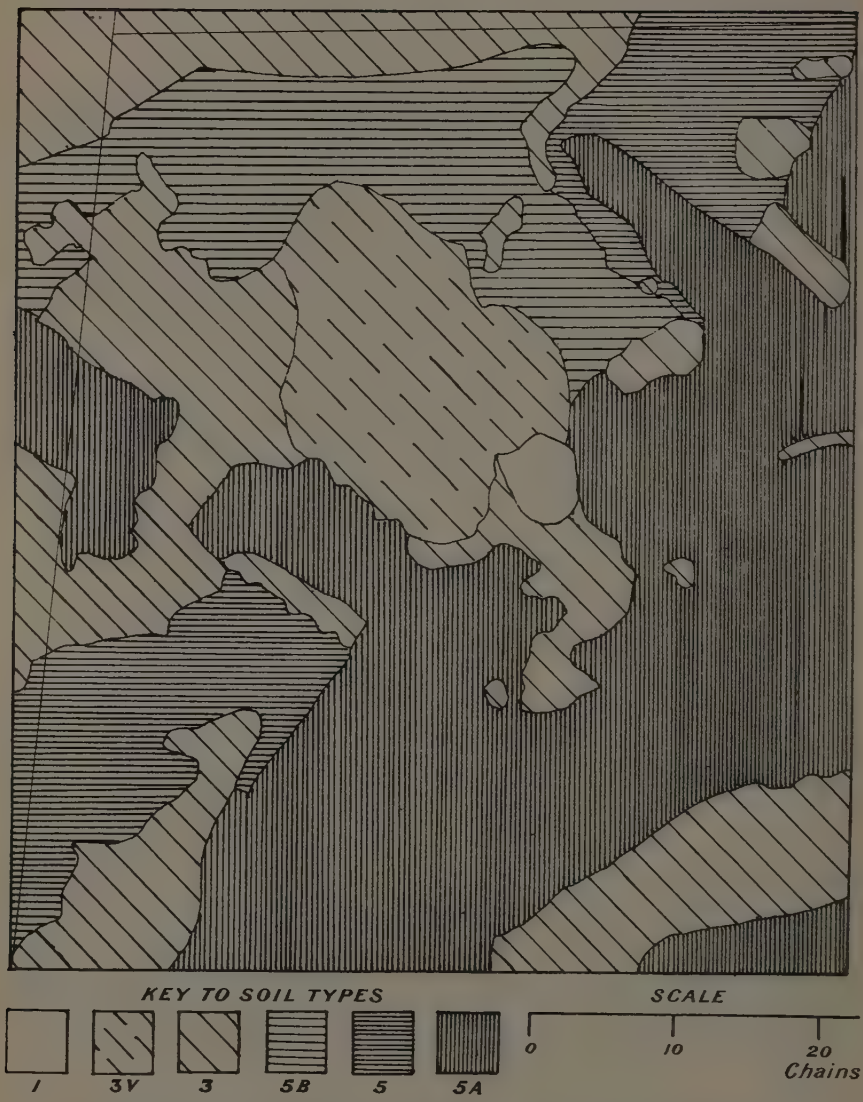

FIG. 3.—Key map to Fig. 1. Figures in circles indicate soil type and location of borings. Letters indicate respectively: B, box; *Sb*, saltbush; *Bb*, bluebush; S, samphire; WS, windswept; and G, grass.

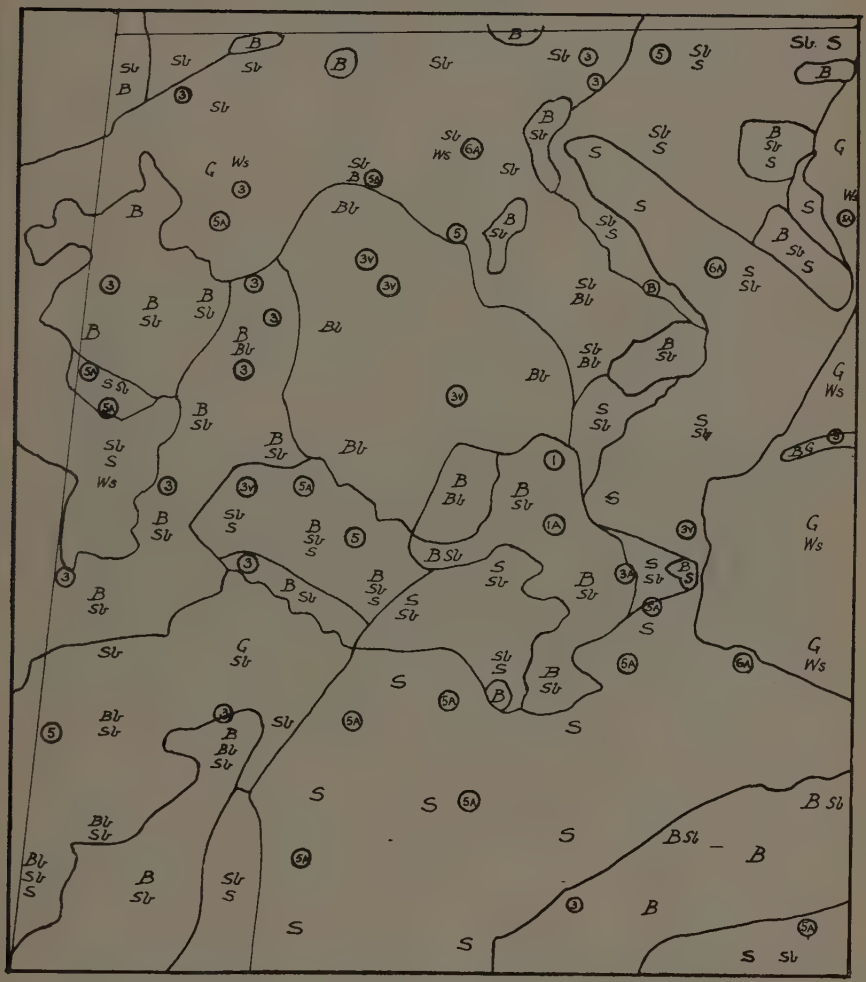

FIG. 3.—Key map to Fig. 1. Figures in circles indicate soil type and location of borings. Letters indicate respectively: B, box; Sb, saltbush; Bb, bluebush; S, samphire; WS, windswept; and G, grass.

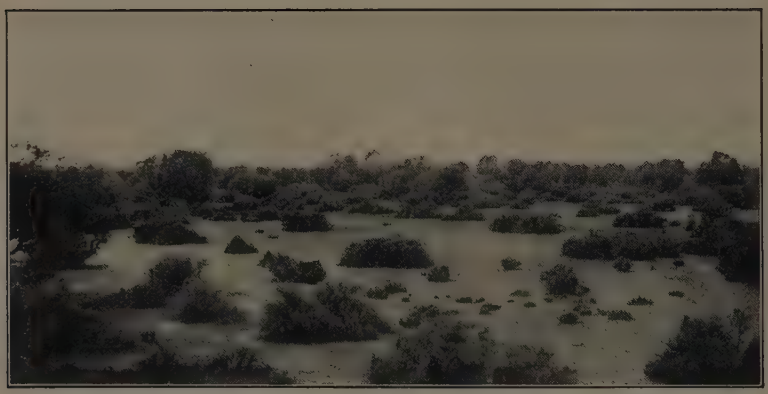

FIG. 4.—Typical vegetation association in virgin country at Renmark. In the foreground, saltbush and samphire associated with soil type 5A, with box on type 3 in the background.

NOTES.

Pastoral Investigations: Contributions by Pastoral Research Trust and Empire Marketing Board.

At a conference between the Australian Wool Growers' Council and the National Council of Wool Selling Brokers of Australia, held in Adelaide in June, 1927, it was unanimously decided to make a voluntary appeal for the payment of 2s. per bale on the then coming wool clip of Australia. The objective at the time was to establish a capital fund of £200,000, the income of which could be utilized in pastoral research. At the present time, some £44,000 has been subscribed, and the Australian Pastoral Research Trust Limited has been formed to administer the income obtained from the fund.

Quite recently the Empire Marketing Board indicated that it would be prepared to accept, in principle, the making of contributions up to £3,000 per annum for a period of five years and on a £1 for £1 basis with moneys provided by the Trust. The Board's contributions are being made through the Council for Scientific and Industrial Research. After due consideration of this offer, the trustees of the fund decided to accept it up to the extent of the present income of the fund, namely, £2,000 per annum.

Expenditure from the sum of £4,000 per annum will be controlled by a Committee, consisting of representatives of the fund and of the Council for Scientific and Industrial Research. As at present constituted, the Committee consisted of the following:—Sir David Masson (Chairman), George L. Aitken, Esq. (Chairman of the Australian Pastoral Research Trust), G. Dalziel Kelly (also representing the Trust), and Dr. J. A. Gilruth and Mr. H. R. Marston (Chiefs of the Council's Divisions of Animal Health and Animal Nutrition respectively. The first meeting of the Committee was held late in September, when a programme of investigations was agreed upon.

The programme comprises an extensive investigation of stomach and other worms of sheep which is to be carried out in Queensland, New South Wales, and Tasmania, or, in other words, under three different sets of climatic conditions, each set being typical of large areas of pastoral country in Australia. The work will be carried out on properties kindly made available by the owners.

Studies will also be made with a view to the development of the most economical formula for the feeding of sheep in times of drought. From indications already obtained, it seems possible, by a suitable choice of readily obtained fodders, to improve present practice in drought-feeding quite considerably; in fact, to develop a formula for the compounding of a drought ration that would not only maintain the sheep, but would also result in the production of sufficient wool to repay the major portion, if not all, of the cost of the hand feeding.

Other investigations on the programme laid down by the Committee relate to various aspects of the following sheep problems:—Black disease of sheep, foot rot, urinary disease, caseous lymphadenitis, infertility, and phosphorus deficiency.

Animal Nutrition—Basal Metabolism Studies on the Sheep.

" If we are fully to understand the efficiency of the sheep as a converter of the matter and energy of its foodstuffs into the end products we seek after—whether these be wool or fat carcass—we must firstly study the energy exchange, which represents the food consumed, to support the various metabolic processes which continually go on in the living animal. The amount of energy consumed by the resting and fasting animal is usually referred to as basal metabolism.

The existing estimations of the basal metabolic rate in the sheep which occur in scientific literature are not sufficient for the purpose of estimating minimal rations for hand-feeding of sheep during the nutritional distress which is often realized under Australian conditions.

One of the first problems undertaken by the Division of Animal Nutrition was an extensive study of the fundamental criteria which underly and influence the metabolism and utilization of different classes of foodstuffs by the merino sheep.

A scientific bulletin, which sets out the results already gained from the work with the calorimeter, is in the course of preparation, and will appear towards the end of this year. This will represent the first report of a series of studies on a scientific problem, which must necessarily form the basis for true assessment of the economics of sheep-raising, and is a problem which is essentially Australia's own.

Considerable technical difficulties had to be overcome before satisfactory operation at the calorimeter was secured, but reliable results are now being obtained, and the work is already past the experimental stages.

The basal metabolic rate of the sheep has been found to follow the law which governs all animals, i.e., that the energy output, when at rest and after food absorption has stopped, is proportional to the surface area of the animal, that is, about 900 to 1,200 large calories per square metre of skin per day. Young, well-nourished, ewe weaners consume about 1,200 calories per square metre per day. This is a rather unexpected result, as the insulating effect of the fleece would lead one to expect a much reduced heat output, or, in other words, a more economical animal.

The sheep shows a marked ability to become more economical when the nutritive level falls, and sheep which are slowly losing weight on poor autumn pastures have a basal rate of 980 calories per square metre per day, or only 82 per cent. of that of well-nourished animals on spring pasture.

Sheep on a diet which just maintains their weight, with due allowance for weight of wool grown, are intermediate in economy, their basal rate being about 90 per cent. of that of well-fed animals. In general, male animals show a rate 5 per cent. to 10 per cent. above females, but in the case of wethers the removal of the sexual glands has brought them to a slightly lower level than ewes—about 960 calories per square metre per day.

The skin-area weight relationship of a number of sheep has been determined, and corresponds moderately with the formula:—

Area in square metres = square of cube root of live weight in Kg. multiplied by a constant:—

$$A = K W^{2/3}.$$

However, poorly-developed sheep from the south-east of South Australia required a larger value of K than well-developed ones from the Council's flock at the Waite Agricultural Research Institute.

A rough approximation for all sheep is given by a value of 1/11 for K where A is in square metres and W in kilograms.

A discussion of these results in terms of food values:—

The energy requirement (which is subject to adjustment for protein required for wool growth, body growth, digestive secretions, and bodily wear and tear) is usually calculated as "equivalent starch." One gram of starch in the animal body produces about 4.2 calories; 1 gram of protein, 4.3 calories; 1 gram of fat, 9.5 calories (Loewy's figures).

For animals in fair store condition, about 1,000 calories per square metre per day are required for basal metabolism. To this must be added the requirements for digestion, locomotion, and the extra heat produced owing to ingestion of food. About 20 per cent. of the basal metabolism is usually allowed for these extras. Thus a medium-sized store wether weighing 45 kg. (100 lb. live weight) would have a surface area of about 1.15 square metres, and would require 1.15 x 100 plus 20 per cent., say, 1,400 calories. To generate this heat 1,400 ÷ 4.2 = 333 grams of digestible starch (or its equivalent) is required. Portion of this food must be in protein to allow for wear and tear and digestive loss. The protein for wool growth is required in addition to the above. As wool is a very specialized protein as compared with plant proteins, a large number of units of the latter are required to build one unit of wool; the unwanted residue of plant protein is burnt supplying portion of the energy requirement.

The net gain of energy from each food source is especially interesting in assessing the true fattening value of fodder species and concentrates. Such studies emphasize the point that amounts of protein materials above those necessary for maximum growth are not sufficiently utilized for fattening animals and that the specific dynamic effect of the excess protein causes considerable loss of net efficiency in utilization of the energy contained in whole ration through stimulating the basal metabolic rate.

The assessment of the net energy values for all concentrates and fodders offering on the Australian markets will be carried out during the course of these studies, and this will form an integral part of a much larger scheme for scientifically assessing the monetary value of each available concentrate or fodder for both energy requirements and wool growth. In the latter investigations, the Division of Animal Nutrition has received considerable financial support from the Pastoral Research Fund and the Empire Marketing Board.

—H.R.M.

Flying-fox Problem—Aspects Recently under Consideration.

In a previous number (Vol. 3, No. 1, p. 8), a brief statement on the flying-fox problem of the north-eastern coast of Australia was made.

Since that time, the investigator (Mr. Ratcliffe) has given some attention to the commercial possibilities of making some use of the skin of the animal. He points out, however, that the fox has a body of the approximate size of a half-grown kitten. The wing membranes from the fore limbs to the legs are attached to the sides and divide the fur into back and front regions, which are quite different in quality and thus preclude the possibility of making use of the skin as a whole. The fur of the back region is not over thick, but that of the breast and underneath portions of the animal is all of much better quality, though usually rather hairy. Moreover, the latter thins out considerably near the line of attachment of the wing membranes, which would probably allow of only a small central strip being used. The longest and thickest fur occurs in the "mantle," especially on the back in the region of the shoulder-blades.

Mr. Ratcliffe recently obtained a dozen typical skins, which were then sent to a firm of fur-dressers and dyers for an opinion as to their commercial value. The firm in question—Fur Dressers and Dyers Ltd., of Sydney—afforded most helpful co-operation, and, after incidentally dressing the skins quite free of charge, expressed the opinion that the skins were totally unsuited for commercial purposes.

Mr. Ratcliffe's original appointment of two years will shortly be completed. Before he furnishes a report on the result of his inquiries, and on the possibility of any future lines of investigation, he proposes to give some attention to the question of poisons and repellents which could be placed in orchards. There is some slight evidence which would lead to the belief that it may be possible to obtain an odoriferous material which would be objectionable to the foxes and thus keep them away from the fruit trees it is desired to protect.

New Zealand Department of Scientific and Industrial Research—Annual Report.

The annual report of the New Zealand Department of Scientific and Industrial Research for the year 1929-30 has recently been issued.

Points of interest to Australia and supplementary to the accounts given in a previous issue of this *Journal* (Vol. 1, No. 6) are mentioned in the paragraphs that follow.

In general, the Department is finding, in common with experience elsewhere, that the obtaining of important results in the early years of its establishment seems comparatively slow, but, nevertheless, general progress has been made in a number of directions and along many lines of material use to industry.

Seed and Plant Research Station.—At this station, which is conducted in co-operation with the Department of Agriculture, the main advance has been in connexion with the selection of strains of the Dominion grasses and clovers, such as perennial ryegrass, white clover, red clover, and cocksfoot. Desirable types of ryegrass have been isolated and a quantity of seed is now available for further propagation. A seed certification system, based on productive capacity, is now being employed by the station.

Work on top-dressing is also in progress, and it has been definitely shown by carefully-conducted experiments, extending over five years, that 1 cwt. of superphosphate increases the yield of wheat by 5 bushels per acre, and is highly payable. It has also been shown that by top-dressing phosphated wheat with nitrogen in the spring, a further 5-bushel increase can be realized under New Zealand conditions. Top-dressing with these two materials is now being extensively practised.

Dairy Research.—The Dairy Research Institute at Palmerston North, with the associated laboratories at Hawera and Hamilton, is carrying out work in dairy chemistry and dairy bacteriology. Experiments are in progress to determine the most common sources of contamination of milk, and special attention is being devoted to the effect of contamination from milking machines and to simple practical methods of keeping milking machines clean and free from contamination. Attention is also being paid to the manufacture of cheese, and the following points of immediate application in the industry have been determined:—(i) Milk which develops acid excessively slowly is liable to the production of open-texture cheese—a matter which could be overcome by the use of only the purest milk and an active and pure starter; (ii) excessive salting of cheese curd proves detrimental to the body of the resulting cheese; and (iii) the utmost care should be taken in the packing of cheese-hoops in order to avoid open texture.

Pig Industry.—In co-operation with the agricultural colleges and bacon manufacturers, a fairly comprehensive survey of feed conditions in relation to pigs has been made, and considerable information obtained as to the relation of diet to rate of growth and to the quality of the pork and bacon.

Leather and Skins.—In the leather industry, a Tanners' Research Association has been formed and a laboratory established for the investigation of the technique of tanning processes, the elimination of waste in the industry, the testing of leathers, and the investigation of the tanning value of local barks. Considerable progress has already been made, and at a general meeting of the Association held in June, 1930, the following resolution was passed:—

> "That this meeting desires to place on record the valuable assistance given by the Research Association in—(i) raising the standard of leather produced; (ii) raising the efficiency of production; (iii) improving the co-operation between the tanners and the different branches of the leather consumers. That this resolution be published as an indication to other industries of the benefits to be obtained from the application of research."

Wheat.—By co-operation of millers, growers, and bakers, and the Lincoln and Canterbury Colleges, an active programme of work on wheat has now been in operation for two years. Systematic studies on the selection, breeding, and trial of varieties of wheat from all parts of the world, including their protein content, and the baking qualities of the flour produced, are in progress. It is considered that the work will be an insurance against loss to the growing of faulty varieties on an extended scale. The investigations are carried out by the Wheat Research Institute, which is financed by farmers, millers, and bakers on a £1 for £1 basis with the Department. The institute has a chemical laboratory, an experimental flour mill, and a bakery in Christchurch, in close association with Canterbury College, and a plant-breeding station on ground supplied by Lincoln College.

Wool.—Investigations on wool are being carried out along the following lines:—

(i) Breeding experiments to ascertain the degree of wool character inheritance occurring in the Romney-Marsh breed.

(ii) Detailed studies of fibre development, particularly those relating to medullation, thickened tip, and hairiness.

(iii) A chemical examination of wool grease and yolk, with special reference to fibre nutrition.

(iv) Breeding experiments to ascertain the relation between the birth coat of lambs and the subsequent fleece character.

(v) Experimental feeding trials.

Cold Storage and Transport.—Work is in progress with a view to the determination of the most suitable conditions of cold storage under which the food products of New Zealand may be carried to the English market. Particular attention is being paid to the transport of apples and pears.

Noxious Weeds.—Extensive investigations are in progress on the possibilities of controlling noxious weeds by means of beneficial insects. During the period covered by the report these researches have been confined to the control of blackberry, ragwort, gorse, and piripiri. The first named constitutes a difficult problem, owing to the close botanical similarity the pest has to the raspberry. Four consignments of an insect—*Coraebus rubi*—have been received from the south of France. The work on ragwort has been confined to a study of *Tyria jacobaeae,* and encouraging results have been obtained from several liberations that have been made. This insect is now firmly established in the areas where it was first liberated, and a further 200,000 specimens have now been distributed to all provinces in which ragwort occurs. During the year, seven consignments of *Apion ulicis* were obtained from England. This particular insect is giving indications of being very useful in the control of gorse.

Fruit Research (*Horticulture*).—Arrangements are being made for the acquisition of a suitable experimental orchard property on which to carry out the programme of horticultural research which is proposed.

Forest Biological Research Station.—This station is being erected by the Cawthron Trust Board and will consist of three small laboratories, one large general laboratory, and a library and committee-room. In the meantime, the staff is being housed at the Cawthron Institute itself. In view of the large afforestation schemes which are being developed by the State Forest Service and many private companies, a considerable amount of attention is being paid to the control of the insect pests of exotic timber trees. Here again use is also being made of beneficial insects. For example, a number of specimens of *Rhyssa persuasoria,* which parasitizes the timber pest *Sirex juvencus,* have been liberated in infected stands of timber.

General.—It should be realized that the foregoing account touches on but a very few of the many investigations the Department is carrying out. It is quite obvious from a perusal of the full report that with so many of New Zealand's problems being energetically investigated, the influence of the Department will be felt to an ever-increasing extent.

Investigations on Apple Thrips.

From time to time, species of thrips appear in phenomenal numbers in Australian apple and pear orchards and cause much damage. The insects, which appear in the spring, enter the flowering bud and, due to their feeding on the pistil and stamen, the fruit fails to set and a heavy loss of crop results. The severity of the attack varies considerably from spring to spring, being sometimes negligible in its effect, but often, as already stated, quite the reverse.

Practically all States of the Commonwealth are affected. In Western Australia a serious outbreak took place in 1915, and again in 1927. In New South Wales bad outbreaks occurred in 1913, and again in 1926; and in Victoria a serious loss was experienced in 1926. The Stanthorpe district of Queensland is also known to have suffered from infestation. In heavily-infested districts the loss of crops due to the pest ranges from a total loss to one of about 60 per cent.

At the present time, comparatively little is known of the life-history of the pest (probably *Thrips imaginis*), and consequently the most effective and economic control measures are difficult to formulate. The Council's Division of Economic Entomology has been able to detail an investigator (Mr. J. W. Evans) for an investigation of the problem, and a commencement of the work has recently been made.

The programme of work that has been laid down includes the following:—The determination of the number of species involved in the outbreak, and their correct names; the working out of their life-histories and a study of the effects of climatic conditions on the various stages; the investigation of host plants, other than the apple and pear; the investigation of various possible cultural methods of control; and the investigation of the factors which induce a big outbreak and the possibility of predicting such outbreaks beforehand.

No possibility of the control of the pest by other insects presents itself at the present time, but inquiries will be made as to the existence of natural enemies in various parts of the world. The problem is not one that offers much hope of rapid or spectacular results. The pest is dangerous, because of the unexpectedness of its appearance and the rapidity of its attack; and one of the main hopes of preventing the losses it so frequently brings about will be in being able to warn orchardists when to be prepared and what preparations to make in order to check an outbreak most effectively.

For the time being, the work will be largely confined to Victoria, where it will be facilitated to no little extent by the co-operation of the local State Department of Agriculture, which has been freely given. In particular, the Department has arranged for the investigator to be provided with laboratory accommodation in Melbourne at its research station situated at Burnley.

Division of Animal Nutrition—Sir Charles Martin.

The Council has recently been fortunate in obtaining the services of Sir Charles Martin, C.M.G., D.Sc., F.R.S., &c., as Chief of its Division of Animal Nutrition in succession to the former chief, the late Professor Brailsford Robinson. The University of Adelaide, in the grounds of which the Division's laboratory is placed, has been particularly helpful in connexion with the whole arrangement.

For many years past, Sir Charles has been the Director of the Lister Institute, London, but before joining that institute he was for a number of years on the staffs of the Universities of Sydney and Melbourne, being appointed Professor of Physiology in the last-named place in the year 1901. He has thus spent a very considerable part of his life in the direction of researches connected with physiological and pathological subjects and, in addition to publishing numerous scientific papers on a variety of subjects, has obtained a very wide experience that will be of outstanding value to the Council, not only in connexion with the work of the Division of Animal Nutrition, but in other directions as well.

It is expected that Sir Charles will reach Australia, per the steamship *Ceramic,* late in February, 1931. In the meantime, he is collecting an amount of specialized information on animal nutrition that is available in research organizations in Great Britain and on the Continent. He was also a representative of Australia at the recent wool conference that was held in Great Britain to consider, *inter alia,* the organization of Empire research as regards wool. This conference was attended by leading research authorities from the various parts of the Empire, and the personal contacts Sir Charles was thus able to make will be of no little advantage to him during his forthcoming work in Australia. On the way out to his new sphere of operations, he will spend a short time in South Africa, where he will visit the well-known veterinary research station at Onderstepoort, near Pretoria, and will also follow an itinerary prepared by Sir Arnold Theiler and Dr. Du Toit.

Imperial Bureau of Fruit Production—Visit to Australia of the Director (Mr. R. G. Hatton, M.A.).

Arrangements have been made for the Director of the recently-established Imperial Bureau of Fruit Production (Mr. R. G. Hatton, M.A.) to visit Australia and other parts of the Empire. He will reach New Zealand, from Canada, some time about the middle of November, and, after spending some two or three weeks in that Dominion, will come on to Australia, arriving at Sydney towards the middle of December. An itinerary for his Australian visit has been prepared, and includes visits to the eastern States. Mr. Hatton has to leave Australia by the middle of February, and it is accordingly unlikely that he will be able to visit Western Australia. From Australia he will travel home via Java, Ceylon, and India. Thus at the end of his travels he will have seen typical examples of the different types of fruit productions throughout the Empire.

The costs of the whole tour are being borne by the Empire Marketing Board.

For a number of years past, Mr. Hatton has been the Director of the East Malling Research Station, England, which specializes on problems relating to the production of those varieties of fruits grown in the British Isles. On the formation of the various new agricultural research bureaux under the scheme recommended by the Imperial Agricultural Research Conference of 1927 (see this *Journal*, Vol. 2, No. 2, p. 82), the Bureau of Fruit Production was established at East Malling, and Mr. Hatton occupies the dual position of Director of both organizations. This arrangement has facilitated the operations of the Bureau very considerably. Three scientific officers have been appointed to the staff of the Bureau, and between them they have a working knowledge of French, German, Italian, Dutch, and Spanish. As a result, the scientific literature on fruit-production in all these languages as well as in English is abstracted and made readily available to the research workers in the field of horticulture throughout the Empire.

In a recent article descriptive of the Bureau, Mr. Hatton has pointed out that from the first it was obvious that the Bureau would have to collect information covering a very wide field and concerning researches initiated with different objectives in view. For example, he states that—"Whilst the primary preoccupation of one Dominion had been the breeding and selection of fruit plants suitable to its particular climatic conditions, that of others was the conservation, storage, and transport of an all-too-plentiful fruit harvest. Again, the production of high-quality produce, through a more perfect economic control of diseases and pests, was the foremost problem of one group of investigators, whilst the possible application to tropical crops of the broad principles involved in deciduous fruit-growing was interesting the representatives from many Crown Colonies. Meanwhile, at a comparatively recent date, there had grown up in this country a highly-developed fruit culture a programme of intensive research upon the nature and responses of the fruit plant, and the functioning of its constituent parts, under given conditions."

Circular letters have now been sent out to horticultural investigators stationed in the various parts of the Empire, and an index of the researches being carried out is being prepared. The Bureau will accordingly be able to function as a source of ready information regarding the lines of any particular investigation initiated in any part of the Empire. In this way, it will serve as a most useful means of avoiding duplication.

There are many other directions in which the Bureau is beginning to carry out useful work. To mention two only, for instance—it is collecting all the data available on the effect of external factors, such as soil and climatic conditions; and also on orchard practices, such as pruning, manuring, and methods of cultivation, &c.

Division of Plant Industry—Statistical Studies.

For the last two years Miss Frances Allan, a mathematical graduate of the University of Melbourne, has been at the Rothamsted Agricultural Research Institute as a student under the Science and Industry Endowment Fund. Whilst at Rothamsted she obtained an amount of experience in the application of statistical methods to agricultural

experimental work which of recent years has been so developed at that place as to become a very potent means whereby to extend the limits of existing agricultural knowledge.

Miss Allan returned to Australia in September last, and has now been appointed to the staff of the Division of Plant Industry. She has been stationed at Canberra, and, for the time being, will concentrate on the following programme:—

(i) Statistical studies concerning the breeding of the principal crops of Australia, with special reference in the first instance to wheat.

(ii) The collection and collation of information on climatic conditions appearing at various stages of growth, and their influence, &c.

(iii) The analysis of data from uniformity trials and field experiments.

Imperial Geophysical Experimental Survey—Final Report.

The agreed-upon two years' programme of field work of the Imperial Geophysical Experimental Survey was completed in the early months of the present year (1930). Subsequently, by the kind co-operation of the various States Departments of Mines, some of the results of the Survey and its predictions regarding the probable existence of ore bodies, were tested by means of bores, and, in one or two instances, by costeaning and shaft-sinking. This confirmatory work, by its very nature, was slow, and it was only after the lapse of some months that the complete results of the work that had been done became available. Moreover, owing to the somewhat costly nature of boring work, it was not practicable to put down all the bores that were suggested by the Survey.

Briefly, this confirmatory work of the States Departments has yielded the following results:—In Queensland, three bores put down at Mungana have resulted in the location of one probably small low-grade copper-bearing deposit; several other Queensland indications of the Survey, however, are at the present time untested. In Victoria, where most of the work done was carried out by gravitational methods, the forecasts of the section concerned in regard to the delineation of the underground extent of a brown coal deposit at Gelliondale have been fully confirmed by five critical bores. In Tasmania, the existence of two previously unknown copper-nickel lodes has been fully proved by costeaning; the precise position of a continuation of a pyrrhotite lode in the Renison Bell district has also been confirmed by three bores. In South Australia, a previously unknown deposit of graphite has been proved by means of a drive put out from an existing shaft. In some other localities, the bores have resulted in information of value to the Survey.

In the interval during which the above confirmatory boring work was being carried out, the Director of the Survey and some of its officers had returned to England. In addition, some of the members of the executive committee which controlled the Survey were also in England in connexion with other matters. Advantage was accordingly taken of

this position to finish the final report of the Survey in England, to discuss its publication, &c., with the authorities of the Empire Marketing Board (which contributed half the funds of the Survey), and also to consult various eminent authorities or referees in regard to the results the report disclosed, its form of presentation, &c. As a result, it has appeared that the report will be received very favorably by informed opinion in Great Britain. The British Department of Scientific and Industrial Research, for instance, has recently set up a Geophysical Research Committee, with the main object of encouraging and advising on future geophysical work in Great Britain. That Committee recently considered the report of the Survey, and also comments made by referees to whom sections of particular interest to each particular referee had been submitted. In a recent letter the Department states that the report "was an impressive record of work which was very creditable to all concerned, especially having regard to the difficulties which had to be overcome. Equally creditable, as evidenced by the remarks made by the referees, was the way in which the report had been prepared, and it was considered that it would be a valuable contribution to the literature of applied geophysics."

The report itself will consist not only of the findings of the Survey, but a large part of it will consist of a detailed description of the various methods of geophysical prospecting that were used. The volume will accordingly serve as a text-book on geophysical prospecting, as well as constituting a record of work carried out under field conditions in Australia.

The report will be published by the Cambridge University Press, and it is expected that the printed copies will be available to the public early in 1931.

Division of Forest Products—Dissemination of Information.

The Division of Forest Products is finding that an important need of the Australian timber industry is the further dissemination of information available as the result of investigations already carried out by various bodies, both in Australia and elsewhere.

It is accordingly taking some steps in this direction, and as part of its general activities in the dissemination of information, is shortly issuing a series of trade circulars which will be made available to sawmillers and which will describe, in quite simple language, methods of present practice. Each circular will deal with one aspect only. The first will discuss the care necessary in air seasoning, and the second some simple methods of estimating the moisture content of timber, in order to ascertain whether it has been sufficiently seasoned or not.

In addition, it is proposed to hold, from time to time, short but intensive classes in seasoning. The first of a series of such classes for the training of seasoning kiln operators was recently held at the headquarters of the Division in Melbourne. It was continued for a week, and consisted of lectures, laboratory work, and visits to kiln installations. Fifteen students, drawn mainly from the Creswick Forestry School, but including operators actually engaged in the trade, attended. Other classes will be held as opportunities arise in the future.

Industrial Research in the United States of America.

The amount of attention given to research by industries of the United States continues to increase. As the result of a recent survey, it appears that no less than £20,000,000 is being spent annually by American industry on this form of activity.

In a recent report on this development, it is stated that the larger industrial companies have, in general, such extensive, efficiently-staffed, and well-equipped research branches that they are in an extremely strong position. Each of these research organizations serves to keep the industry which owns them fully abreast of the ever-changing demands of industry in general, and thus is a most important insurance against losses that were formerly incurred owing to products becoming obsolete and being superseded by the products of other industries.

More than 600 industrial concerns maintain research laboratories, and between them expend some £15,000,000 annually on research. The remaining £5,000,000 per annum is made up of expenditures incurred by specially-organized research associations, generally run on a co-operative basis, by a number of manufacturers having a common interest.

The importance placed on industrial research in America will be obvious from a consideration of the above figures. In fact, as stated in the report, "Many large American industrial organizations can trace their success almost entirely to scientific research. . . . Only in a few instances have the industrial research departments failed to produce a considerable profit to the manufacturer, and in scores of instances the ratio of profit to the amount expended has ranged from 100 to 1,000 per cent."

The United States Department of Agriculture.*

The practical and extensive aid given to agriculture by the Federal Government in the United States of America is shown by a study of the organization and manifold activities of the United States Department of Agriculture.

The Department exists primarily to advance the welfare of agriculture in all ways consistent with the welfare of the community as a whole. All the Department's activities may be divided roughly into six general classes:—(i) Research, (ii) extension and information, (iii) eradication or control of plant and animal diseases and pests, (iv) service activities such as weather and crop reporting, (v) administration of regulatory laws, and (vi) road construction.

The personnel at the present time numbers 25,000, of whom 5,000 are in Washington and 20,000 in the field. The Department's expenditure during 1929 was $76,000,000, and it is one of the ten major executive Departments of the Federal Government.

Organization.—At the head of the whole Department is the Secretary of Agriculture, who formulates and establishes the general policy and supervises the whole of the work. He is aided in this by the Assistant Secretary and five directors. These last, each of whom has under his

* Based on a recent publication of the Department entitled "The United States Department of Agriculture—Its Growth Structure and Functions," Miscellaneous Publication No. 88.

charge one particular sphere, are designated as follows:—Director of Scientific Work, Director of Regulatory Work, Director of Extension Work, Director of Personnel and Business Administration, and Director of Information.

The function of these directors consists in co-ordinating the various activities so as to avoid duplication, to save time and money, and to forward a sound agricultural programme. These five directors have under their special care the work connected with the experiment stations, of which some 50 or more (exclusive of 700 field stations) are in existence.

In addition to the units supervised by these directors there are fourteen bureaux, each supervised by a chief, who reports direct to the Secretary. The wide field covered by the activities of the Department is shown by these bureaux, which are as follows:—Bureaux of Agricultural Economics, Animal Industry, Biological Survey, Chemistry and Soils, Dairy Industry, Entomology, Food and Drug Administration, Forest Service, Grain Futures Administration, Home Economics, Plant Industry, Plant Quarantine and Control Administration, Public Roads, and Weather Bureau.

All the bureaux and officers are served by a large central library, the total collections of which, exclusive of those of the Weather Bureau, now number approximately 214,000 volumes. The dissemination of information necessitates the printing of 30,000,000 copies of publications annually. It requires the work of a press service, a vast extension service, an office of exhibits, an office of motion pictures, and a radio service.

Relationship with State Universities.—Apart from the Federal Department, there are in America—as in Australia—State activities to deal with agricultural problems. These are mostly State colleges and experiment stations. The work of the Federal Department is co-ordinated with these activities. In some cases this co-operation is made binding by formal agreement or by the control of funds, while in other cases the co-operation is purely voluntary. A special committee has been formed by representatives from the State colleges and the Federal body to correlate the scientific research work. In regulatory law administration, which is one of the major functions of the main Department, it is often necessary for the Department to establish contacts with State agencies, and this is done under the supervision of the Director of Regulatory Work.

In research work in general, the Department centres effort on national problems, interstate problems, or problems the solution of which may require facilities not possessed by the States. The State colleges, experiment stations, and State Departments of Agriculture deal with more localized problems.

Research Work.—Research now dominates all the work of the Department, its service, regulatory, and educational activities, as well as its scientific projects. Knowledge gained is communicated to the public, used in the particular direction in which it is required, and, if necessary, incorporated into regulatory law administration.

It is possible to distinguish between research work for more or less well-defined practical objects and fundamental research for the discovery of basic facts and principles. The first type is undertaken on a specific problem such as a particular plant or animal disease, or to

develop plant varieties or strains of live stock suitable to particular conditions, or to find new uses for crop by-products. Fundamental research is primarily to increase the sum of knowledge rather than to attain any specific tangible advantage in the first instance.

Both types are carried on in the Department, although there is more research done on specific problems, because funds are usually appropriated for such purposes. As a matter of fact, in practice, the line between the two types of work is not easy to define clearly. Work started for a particular purpose fails until its scope has been widened to include a study of the basic elements involved. Some of the research successfully carried out by the Department in the past illustrates this point. For example, research in the phenomena of round-worm infestation of swine led to a development of a swine sanitation system which probably saves the sum of $1,000,000 a year to farmers in the district where it is followed. Control of hog cholera followed the discovery that the disease is caused by a filterable virus, and fundamental research into the mosaic diseases of plants had far-reaching practical results towards their control or eradication. Specialized research in the Department to-day touches every phase of agriculture as well as many related problems.

Finance.—The first Government grant towards expenses for agricultural work was made in the United States of America in the year 1839, when the sum of $1,000 was appropriated by Congress "for collecting and distributing seeds, prosecuting agricultural investigations, and procuring agricultural statistics." Expressed in British money, the appropriation provided for the fiscal year ending 30th June, 1931, amounts to £16,400,000, exclusive of money for road construction which is controlled by the Department, and which is alone responsible for an appropriation of about £19,000,000 per annum.

An analysis of the expenditure during 1929 classified by the type of activity is of interest. In pounds sterling roughly £3,500,000 was spent on research work, £2,000,000 on extension work, £2,400,000 on eradication and control, and the remainder on service activities and regulatory work.

Recent and Forthcoming Publications of the Council.

Since the last issue of the *Journal,* the following publications have been issued:—

Bulletin No. 44.—"Spotted Wilt of Tomatoes," by G. Samuel, M.Sc., J. G. Bald, B.Agr.Sc., and H. A. Pittman, B.Sc.Agr.

Bulletin No. 45.—"A Soil Survey of the Woorinen Settlement, Swan Hill Irrigation District, Victoria," by J. K. Taylor, B.A., M.Sc., and F. Penman, M.Sc.

The following publications are now in the press:—

Bulletin No. 46.—"Studies on Black Disease (Infectious Necrotic Hepatitis in Sheep," by A. W. Turner, D.V.Sc.

Pamphlet No. .—"The Influence of Frequency of Cutting on the Productivity, Botanical and Chemical Compositions, and the Nutritive Value of Natural Pastures in South Australia," by Dr. J. G. Davies and A. H. Sim.